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JOURNAL
OF THE
AMERICAN PEAT SOCIETY

A QUARTERLY JOURNAL DEVOTED TO THE DIFFU-
SION OF KNOWLEDGE OF THE UTILIZATION OF
PEAT, AND THE DEVELOPMENT OF
AMERICAN PEAT RESOURCES.

VOLUME XII.

JANUARY, 1919, TO OCTOBER, 1919.

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Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York, City.

• Dear Sir:—

I, the undersigned, being interested in the development of our peat resources and in the welfare of the peat Society, beg to make application to membership in your Society, for which I enclose \$5.00 as annual dues.

Signed

Address

.....

Date.....

Journal of the American Peat Society

Vol. XII

JANUARY, 1919

No. 1

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CHANGE OF EDITOR'S ADDRESS.

During the last four months the editor has found it necessary to be away from his office a large part of the time, and therefore several matters in connection with the Journal have been delayed. The editor has also found it necessary to change his office to Hackettstown, N. J., and it is now hoped that matters concerning the Journal will receive prompt attention.

ANNUAL DUES.

At the annual meeting the Secretary presented a tentative plan for increasing the membership of the Society which would result in a reduction of the annual dues from \$5 to \$2.50. Our members are aware of the plan, which has been communicated to them by our Secretary. The plan was to endeavor to increase the membership to such a point that the Society could afford to reduce the annual dues; it is with regret we have to advise that this end has not been accomplished, so that the dues will still remain \$5 for 1919.

PROCEEDINGS OF THE ANNUAL MEETING.

The annual meeting was held in New York on September 25th and 26th, 1918, at the McAlpin Hotel. Owing to the war there was not a very large gathering, as had been anticipated, but the main object was to elect new officers, at the request of the President, Mr. Luther B. Arnold, of Duluth, Minn. A quorum was present for this purpose, and the following officers were elected for the ensuing year:

President.....Prof. Peter Christiansen
St. Paul, Minn.
First Vice President.....B. F. Haanel
Ottawa, Can.
Second Vice President.....Prof. H. C. Thompson
U. S. Bureau of Soils, Washington, D. C.
Secretary-TreasurerCharles Knap
17 Battery Place, New York City.

Executive Committee—

John N. Hoff, Chairman.....17 Battery Place, New York City
 G. Herbert Condict.....922 Central Ave., Plainfield, N. J.
 Arthur J. Forward.....Ottawa, Can.
 Herbert PhillippHackettstown, N. J.
 Ernest V. Moore.....Montreal, Can.

Prof. Thompson gave a very instructive talk on the several years of work conducted by the U. S. Department of Agriculture in co-operation with the American Peat Society on peat soils, under his supervision, and we hope to be able to publish this paper at a later date.

B. F. Haanel related the work and aims of the special Peat Committee working under the jurisdiction of the Dominion Government. Work has not proceeded far enough yet to allow too many statements to be made at this time, however, after their working plans have further matured a statement will be forthcoming.

A paper by Clarence C. Osborn of the U. S. Geological Survey, appears in this issue.

PEAT PROSPECTS.

Those who have worked in peat during the last year have no complaint to raise regarding the disposition of their product, the peat business, to the contrary, has been called upon to deliver more product, whether as fertilizer or fuel, than could possibly be turned out.

Owing to the fact that machinery and machine parts were difficult to obtain and could only be had after continued delays, together with the inability to obtain skilled mechanics explains partly the inability of the peat industry to have reached a point far above the preceding year.

The peat industry, however, has come to stay with us and an ever increasing demand and extended utilization of the material, both in agriculture as well as the industries, can be looked for. Peat in agriculture is becoming daily more in demand on account of its qualities in this direction becoming more widely recognized and accepted.

The beneficial effects of its utilization has frequently been referred to in the pages of our Journal, yet it will not be amiss to recapitulate them here. Firstly, the ability of peat to retain water, serve to dissolve plant food and also is the means of conveying plant food to the plant itself, whilst water itself constitutes an important plant food. The mixture of peat with soils, either alone or together with other fertilizer ingredients, allows the soil to become loose and thus favors aeration; air is

a plant food, supplies also food for plant bacteria and aids the plant in germination. The humus material present in peat serves also as plant food as well as increasing the amount of available plant food. Peat is an excellent medium for bacterial cultures which are necessary in the soil to make plant food available and to destroy organic matter, making it more assimilable for plant food.

Peat as fuel is also finding a welcome berth in such parts of the country where coal is high in price and still hard to obtain. The outlook is that coal will not come down low enough in price to allow the peat fuel manufacturers to store their machinery; on the contrary, where peat can be locally used, its consumption will gradually increase, the more so as soon as the domestic users become better acquainted with its virtues.

PEAT GASIFICATION AND AMMONIA RECOVERY.

Neither the American Peat Society nor the U. S. Government were tardy in realizing the possibility of recovering the latent nitrogen in our peat resources as ammonia, and the Society was earnestly using its efforts with the Departments in Washington to erect a gas producer with ammonia recovery to attain this end. In fact, your editor was very actively engaged in this direction and matters had developed to such a stage that the possibility of erecting a plant was evident when the signing of the armistice temporary stopped further procedure.

The recovery of ammonia and the production of power from peat, when properly handled, appears a very profitable undertaking, however, the installation cost for a commercial plant is somewhat heavy. Yet the economic utilization of peat in this direction will some day appeal to our capitalists and we hope that the time will not be too long deferred. Our peat resources are vast and the economic exploitation of the same will be a benefit to the country as well as to the investors, provided the project is under the proper care of intelligent engineers.

ROLL OF HONOR.

Prof. John T. Stewart, of Agricultural College, St. Paul, Minn., has been in the military service since May, 1917, as Lieutenant Colonel of Engineers.

PEAT IS A FERTILIZER INGREDIENT.

Those who have endeavored to introduce peat as a fertilizer, at one time encountered considerable difficulties, to be recognized by the various agricultural experiment stations. Later this material was allowed and recognized as a filler and

drier. We are now arriving at a period of the peat fertilizer industry where peat, properly prepared, is being recognized as a plant food and fertilizer ingredient.

Any material which does not contain appreciable quantities of nitrogen, potash or phosphoric acid, added to high grade fertilizer, primarily to reduce the percentage of fertilizer ingredients, and secondarily to improve its mechanical condition, is called a filler.

The term, low grade fertilizer materials, is used to designate two distinct conditions in the fertilizer trade; in the first case, to define the material in which the amount of plant food present is much less than that contained in other materials, known as high grade; in the second case, to indicate that the plant food is of low availability.

Many manufacturers, in order to overcome the necessity of using fillers, use low grade materials to reduce high grade materials to a lower percentage of plant food. These low grade materials serve not only as diluting agents and driers, but also as sources for plant food. Hence, to use the word "filler" in connection with dried peat and similar materials is incorrect.

SWEDISH OIL INDUSTRY.

Considerable propaganda has been started in Sweden for working up a domestic oil industry and in this connection considerable mention has been made of the peat bogs which exist there as a source of oil. Good air-dried peat gives, by dry distillation, 5-8% of tar, from which may be extracted lighting, motor and lubricating oils, as well as paraffine and creosote. Peat has the advantage over slate, in that by distillation it gives 30% of peat coke of a splendid quality so that no residue is left. This is the weak point in the slate distillation which is also being advocated where in the retort a residue is left, the weight and volume of which are about the same as that of the raw slate. In favor of the slate, on the other hand, is the fact that it is found in a natural condition and in enormous quantities on a small area. Peat must first be produced on a large area and in seasons, while the slate mining can be carried on all the year round.

Peat Fertilizer.—J. N. Hoff, U. S. P., 1,261,025, April 2, 1918. Humus is digested with phosphate rock and acid phosphate (superphosphate) in order to produce reverted phosphate and to render the nitrogen of the humus more available. The mass is neutralized and digested again. It is then inoculated with bacteria and dried till the moisture is reduced below 30%, whereby many of the bacteria are converted into the spore state. The mass is again inoculated with suitable bacteria.

Possibilities of Peat

By C. C. Osbon,

United States Geological Survey, Department of the Interior.

General Statement.

The peat deposits of the United States constitute one of the great undeveloped natural resources of this Nation. Vast areas in which this material has long been accumulating are, as you of course know, found throughout Minnesota, Wisconsin, Michigan, New York, and the New England States, in the northern parts of Iowa, Illinois, Indiana, Ohio, Pennsylvania, and New Jersey, on the Atlantic Coastal Plain from New Jersey to Southern Florida, and along the Gulf Coast from Florida to the Mexican boundary. Although it is impossible with data at hand to determine accurately the quantity of peat in the United States, it has been conservatively estimated by Professor Davis that about 11,000 square miles of swamp land contain peat beds of good quality, and that the total available peat suitable for commercial use in these deposits would amount to more than 12,000,000,000 tons. The total quantity of peat marketed in the United States in 1917, the record year in the peat industry, was 97,363 short tons, and the total amount produced since the beginning of the industry, 466,020 tons. It appears, therefore, that our vast peat beds, located in the most densely settled sections of this country and distributed over a wide area, contain an immense quantity of raw material upon which many important industries may be based.

The existence of such a wealth of readily available raw material, even in normal times, would attract much attention, but with the country at war and the consequent shortage of many minerals for which peat may be substituted, a new significance is given to the uses and possibilities of this material.

The purposes for which peat is used are numerous and varied. In the countries of northern Europe it is used for fuel and as the basis for many manufacturing industries. Gas, charcoal, coke, and a number of valuable by-products are produced from it. Owing to the scarcity of raw materials in Europe, peat moss is also employed as a substitute for absorbent cotton in the preparation of surgical dressings, for wood, and for cotton and woolen cloth. In the United States peat is

*Read at the Annual Meeting, New York, Sept. 26th, 1918.

utilized chiefly as fertilizer and fertilizer filler, as stable litter, and as an absorbent for the uncrystallized residues of beet and sugar refineries in the manufacture of stock feed. It is obviously impossible on an occasion of this kind to discuss all the uses of peat, so I shall confine myself to its uses as fertilizer and fuel, which, I believe, present the greatest possibilities in this country.

Fertilizer.

The scarcity of available nitrogen, one of the vital requirements for plant growth, has long been a problem in the United States, even in normal times. With the virtual commandeering by the Government at the outbreak of the war for the use of the explosives industries of practically all nitrate imported from Chile or produced in this country in retort ovens, the stringency confronting the fertilizer industry has become acute, and it seems that the peat deposits are one of the few domestic sources of nitrogen that can be converted into plant food at a price that is economic to the farmer. Analyses of the peats of the United States show an average nitrogen content of about 2 per cent, although many peats contain more than this. Peat has long been used in fertilizing the soil, having been either applied as a direct fertilizer or used as a fertilizer filler. Its value in soil fertilization is found in its nitrogen content and in the beneficial mechanical effect it produces upon certain lands. Many of the large manufacturers of commercial fertilizer are depending upon peat almost exclusively for their nitrogen. Black, thoroughly decomposed humus is most satisfactory for this purpose, as such material is generally more compact and contain more nitrogen and less fibrous matter than the brown types.

Bacterized peat is said to be an even more prolific source of soluble nitrates than the crude material. A culture bed of peat, if treated with a dilute solution of ammonium sulphate and then inoculated with nitrifying organisms, is said to yield after one treatment 0.82 per cent of nitrates and after repeated treatment about 4 per cent. It has not yet been shown that this process is adapted to the production of nitrates on a commercial scale, but in view of the rare occurrence and present shortage of these salts, which are so essential to agriculture, the process strongly invites further and larger experiment. If the only change effected, however, is to convert to a nitrate the nitrogen supplied to the peat in the ammonium sulphate, the value of the process is questionable.

A more practicable method of increasing the nitrogen content of soils by means of peat is proposed by Professor Bottomley of King's College, London. It is well known that if peat is exposed to the air for about two years it is neutralized by the formation of ammonia, and a large proportion of the insoluble material is converted into food available for plant life. By inoculating the peat with aerobic bacteria it is found possible greatly to accelerate this change and to increase materially the quantity of plant food. The problem, however, was not to discover a fertilizer, but to find a medium in which nitrogen-fixing organisms could be cultivated and placed on the soil. This medium is found in the peat treated with aerobic bacteria. To prepare it for inoculation the peat is kept moist at a temperature of 26°C. for about a week. Steam is then forced through it to insure that all organisms, bacterial or otherwise, are destroyed, and the result is a sterile medium, neutral or slightly alkaline, suitable for the cultivation of plants or of nitrifying bacteria. The sterilized peat is then inoculated with a mixed culture of *Bacillus radicola* and *Azotobacter chroococcum*, which multiply rapidly and soon permeate the entire culture bed. After complete saturation the bacterial growth is arrested by drying the peat, and it is then ready for use. It is reported that the bacteria in this material enrich the soil to which they are applied by extracting nitrogen from the air and converting it into soluble plant food and that, owing to continuous bacterial action, frequent subsequent treatment is unnecessary.

Still further progress in the application of bacteriology to soil fertilization has recently been reported by Dr. Earp-Thomas, of Richmond, Va. According to his process the peat is mixed with tricalcium phosphate and used as a culture medium for nitrifying and other bacteria which produce phosphorus compounds and which, when applied to the soil, react upon and free its natural potash content from insoluble chemical combinations.

Bacterized peat is being used for fertilizer in England with varying degrees of success. In the United States commercial quantities have been manufactured and sold, and it is reported that crops grown upon soil enriched by it yielded a much greater output than could be obtained from the same land treated with commercial fertilizer.

The manufacture of fertilizer is the most successful industry in the United States based on peat. The output of this material in 1917, as reported to the United States Geological

Survey, amounted to 92,263 short tons. Compared with the production in 1916 this quantity is greater by 44,157 tons, or almost 92 per cent, and exceeds the record established in 1911 by 40,530 tons, or about 78 per cent. Of the total quantity of peat fertilizer and fertilizer filler marketed in 1917, 26,850 tons, or about 29 per cent of the entire output, valued at \$256,000, was bacterized. The condition of the fertilizer market, augmented by the demand for large crop yields wherewith to feed both our own people and our Allies, necessitating the intensive cultivation of the soil and the larger use of fertilizer, warrants the expectation of a notable increase in the production of peat. Once the value of this material is fully appreciated, the resumption of normal conditions will not greatly lessen the demand.

For those who propose to enter this branch of the peat industry too much caution can not be observed in selecting a suitable deposit. Before any money is invested a careful survey should be made of the prospective bog to insure that there is a sufficient quantity of peat. Typical samples should be taken from various parts of the deposit and examined to determine their nitrogen content. Only bogs containing peat that is rich in soluble nitrogen and free of chemicals harmful to plant life should be selected. One of the great handicaps suffered by the peat industry in this country has been the lack of uniformity in the humus produced by it, and as the success of a given plant depends upon the character of the material used, too much caution cannot be observed in its selection. If the quality of the material is suitable peat fertilizer plants well located with respect to transportation facilities and market, adequately financed, and efficiently managed, should be successful both now and after the war.

Fuel.

Peat, because of its high carbon content and the fact that it will ignite and burn freely when dry, yielding an intense heat, is used for fuel in countries where the coal supply is below normal requirements. Although in Europe between 15,000,000 and 20,000,000 tons of this fuel are produced and consumed annually in generating heat and power, in the United States, because of the abundance in normal times of coal, which is more efficient and could heretofore be more cheaply prepared and more readily transported to the consumer, only small quantities of peat fuel have been produced, and the interest shown in previous years in its possibilities has been largely scientific

and experimental. However, in recent years the increasing cost of producing coal and the failure of the operators to keep pace with the ever-expanding demand have led to a general advance in price. This condition, aggravated by an appreciable reduction in the visible coal supply and the rapid exhaustion of our forests, has made a marked impression upon economists and others and has created a desire to conserve these materials by investigating and substituting other fuels and sources of power wherever they can be more economically used.

Van Hise, in urging the conservation of our wood and coal reserves, says:

"So far as practicable other products should be substituted for wood. The original forests of the United States contained not less than 850,000,000 acres, having not less than 4,800,000,000,000 feet of merchantable saw timber. This was our magnificent original heritage. The United States as a nation has existed a century and a quarter, and what have we now? In that brief time approximately one-half of the value of our forests has gone.

"So far as practicable substitutes should be used for coal. Even if all possible economies and substitutes are introduced, the most sanguine can not hope that the supply of fuels will be sufficient to meet the needs of the people for more than a small fraction of the time we look forward to as the life of this Nation."

The shortage of coal in the Eastern and Central States that began toward the end of 1917 has also stimulated a wide interest in the peat deposits of the United States and their potentialities as a source of auxiliary fuel, and from the increasing number of requests for information on the subject received by the United States Geological Survey, it seems that the public is willing to consider seriously the use of peat to prevent a recurrence in some localities of the suffering caused by inadequate fuel supplies last winter. The shortage of coal in many European countries that has existed since the beginning of the war is being supplied in part by the increased use of peat, and there is no reason why the United States should not utilize its vast deposits of this fuel.

In the northern peat region there are no known coal fields, except in small sections, notably in Michigan, and the peat deposits are largely confined to States, which, because of their cold climate and extensive manufacturing industries, consume large quantities of fuel. In the southern part of the coastal region, although the climate is mild and the demand for fuel relatively light compared with that in the northern States, there are no local sources or other mineral fuels. The prepara-

tion and storage of peat fuel taken from these deposits would not only increase the local fuel supply and in many communities prevent a recurrence of the suffering caused by the coal shortage last winter, but would release railroad cars that will be vitally needed for other purposes during the war. Peat therefore has great potential value as a source of heat and power; it may be used locally in some states during economic and industrial crisis to prevent a fuel shortage; it may be utilized to conserve our reserves of coal and wood; and in some sections remote from the coal fields, notably New England, it is believed that peat could successfully compete with other fuels for both domestic and industrial use after the war.

The attempts made in past years in this country to produce peat fuel on a commercial scale have not been successful, but that failure appears to have been due not to a lack of market for the product, but to the lack of sufficient capital, to the inexperience of operators, to the failure to recognize that peat fuel is inferior to coal, and to preventable engineering errors.

Many extravagant claims concerning the fuel value of peat have been made, but the sooner its inferiority to coal is recognized the better for the peat fuel industry. Over a million dollars have been spent in this country in trying to produce some form of peat fuel equal to coal in heating value, and yet we have no peat fuel industry. Careful consideration of all the factors involved leads me to the conclusion that there are only two forms in which peat fuel can be marketed commercially in the United States, and these are in the shape of air-dried machine peat blocks and powdered peat. Many attempts have been made both in Europe and in the United States to manufacture peat briquets for commercial use, but though these are more efficient than machine or powdered peat, the process, on account of the high cost of production, has never advanced beyond the experimental stage, so far as I have been able to ascertain. I do not maintain the impossibility of producing peat briquets, but the country needs fuel, and while experimental work is always commendable if properly limited, the methods that have been successful in other countries should be used to supply that need.

Peat in an undrained bog contains about 90 per cent of water, which must be reduced below 30 per cent before the peat can be used for fuel. By thoroughly draining the deposit approximately 10 per cent of the water contained in the peat may be eliminated, but the remainder, which is held in the microscopic plant cells and minute intercellular spaces, resists the greatest obtainable hydraulic force and cannot be reduced far below 70 per cent without drying in the open air or in a

heated chamber. However, artificial drying as a process, requires the expenditure of so much heat in comparison with the heat obtainable from the fuel prepared by this method that it has not proved commercially feasible. Peat fuel should therefore be prepared during the air-drying season, which begins about April 15 and ends in September, except in the southern peat region, where it is sometimes a little longer. As Director Haanel, of the Canada Department of Mines, has so well put it, "the forces of nature, the sun and the wind, which cost nothing should be used, and any improvement in this process will lie in the direction of labor-saving devices."

Air-dried machine peat is suitable for both domestic and industrial purposes. In calorific value a ton of machine peat is equal to about 1.3 tons of wood, .5 ton of good bituminous coal, and .6 ton of anthracite. It is clean to handle and burns freely, yielding an intense heat and producing no sort or other objectionable deposit. For open grates this fuel is nearly ideal, and it is said that peat may be burned in the same stoves as coal and wood. However, the best results for household use could probably be obtained by burning it in a stove with relatively small grate openings and a restricted draft.

For commercial use powdered peat has many advantages over machine peat as it can be more cheaply prepared and more readily handled. If raw peat is allowed to lie in heaps until natural drainage and evaporation have reduced the moisture content to about 50 per cent, it may be prepared for use under steam boilers by driving off about half of the remaining moisture with waste heat from flues or other sources and pulverizing the resulting material. According to Mr. Edward A. Beals, of Hartford, Conn., who has been working with this process, the powdered peat may then be blown with compressed air into the furnace, where, by means of forced draft, ignition is almost instantaneous, and instead of burning on the grate, the peat forms a gas which gives a uniform fire throughout the entire combustion chamber. Good peat thus treated, when burned in furnaces designed to give the most complete and efficient combustion, will give nearly as much energy in the form of live steam as the same weight of powdered coal. According to reports in this country powdered peat has great possibilities, not only for boiler firing but for metallurgic work and for use in cement and other kinds of kilns in which powdered coal has been successfully burned.

Peat consumed in a properly designed gas producer yields gas of good quality and in abundant quantity in comparison with the yield from coal, and also many valuable by-products. This is perhaps the most effective utilization of peat fuel for

generating heat and power, because peat that is to be used in this way does not need to be so carefully prepared nor so thoroughly dried as peat that is to be consumed for domestic purposes or under steam boilers.

Analyses of the peats of the United States show that they are very rich in combined nitrogen, from 70 to 85 per cent of which, a proportion that in some peats amounts to more than 2 per cent of their dry weight, could be recovered in the form of ammonium sulphate in by-product gas-producing plants operated with peat. The crushed peat is fed into the furnace of a gas producer in which combustion is regulated by steam and hot air. The peat burns at the bottom of the feed shaft, and reacting upon the steam, forms water gas and ammonia. These gases are next cleansed of tar by means of a scrubber and are subjected to a fine shower of sulphuric acid, which converts the ammonia into ammonium sulphate and purifies the water gas. After being cooled the water gas may be used under steam boilers, in internal-combustion engines, and for other purposes. It is said that in Italy peat containing 2.5 per cent of combined nitrogen, when treated by this process, yielded 170 pounds of ammonium sulphate per ton. Gas-producing plants using peat fuel are operated in England, Ireland, Germany, Sweden, Italy, and Russia; but in the United States, although experiments have been made, no gas-producing plants are operated with peat.

Work of the Department of the Interior.

The potential value of the peat deposits of this Nation was recognized many years ago by the United States Geological Survey, a branch of the Department of the Interior, charged by law with the duty of pointing out the mineral deposits of the United States and their commercial value. The American Peat Society is intimately acquainted with the excellent work of Professor Charles A. Davis. More than a year ago the Survey realized the added significance given to the peat resources of this country by the war. Since that time it has attempted to supplement the fuel supply by conducting a campaign through its press bulletins to stimulate the production of cut peat by the owners of small bogs and by citizen's associations for home use, of air-dried machine peat for commercial use, and of peat fertilizer for use in agriculture. To meet the increased demand for specific data relating to the quantity of peat and its suitability for use as fuel and fertilizer the Survey has had from one to three representatives in the field since the beginning of the summer, examining the bogs in the major regions of peat accumulation. Much data have been collected with respect to the quantity and quality of this material in

these areas and the geologic reports describing them, which are now in preparation, will be issued free as soon as possible.

From the technologic viewpoint the Bureau of Mines, a branch of the Department of the Interior coordinate with the Geological Survey, stands ready to undertake work to demonstrate the best methods of producing peat fuel whenever funds are available. An amendment to an appropriation bill authorizing the expenditure of \$50,000 to make investigations of peat to determine the practicability of its utilization as a fuel and in manufacturing commercial products, was recently introduced in Congress by Senator Duncan U. Fletcher, of Florida. If this bill becomes law work will probably be done to demonstrate methods of manufacturing peat fuel in the New England States and in other regions where the recent coal shortage was most acute, and of manufacturing fertilizer in the peat areas near or in the great agricultural regions of the country.

The Geological Survey has been criticized in some quarters for not affording funds for the practical application of the results of its research work, but it has no appropriations for this purpose and the scope of its activities under the present law does not extend beyond the sphere I have outlined. However, the Geological Survey wishes to see a large increase in the production of peat and is ready at all times to co-operate with individuals and companies already established in the business as well as with prospective producers.

Future of the Peat Industry.

The time is at hand for the rapid expansion of the peat industry. The demand for peat is universally greater than the supply and the use of peat fertilizer is steadily increasing as its value is appreciated. By supplementing the supply of commercial fertilizer the producers of peat in this country can greatly help in augmenting the production of food with which to feed both ourselves and our Allies and can thus materially assist the Government in the prosecution of the war. The condition of the commercial fertilizer market, the unprecedented growth of this branch of the peat industry in 1917, and the good results reported by many who used peat for fertilizer warrant the expectation of a peat fertilizer industry of large proportions in the near future. In view of these conditions and of the shortage of coal felt last winter in the Eastern and Central States, it seems that the potentialities of our vast peat deposits, proved by the work of Davis and many others, are being widely appreciated. that the peat industry will soon occupy the high position it deserves among the mineral indus-

tries of the United States, and that peat soon promises to take an active part in the commercial progress of this country.

COAL FROM PEAT.

Mr. Samuel C. Davidson, chairman of the Sirocco Engineering Works, Belfast, has patented a method of treating peat and forming it into synthetic coal, which should in some measure meet the serious shortage in the Irish supply at the moment and assist eventually the British supply. Mr. Davidson's method consists of putting back into the peat certain oils washed away from it owing to its proximity to the surface of the land previously disintegrating it and mixing it up with a 15 per cent of pitch dust. The pulp thus formed is subjected to hydraulic pressure, which turns out in square blocks of fuel, which burns well. Many attempts have been made in Ireland to treat peat in a manner that would give it the approximate heating and lasting powers of coal, but most of these were failures, the cost in most cases outrunning the profit. Mr. Davidson's process is simple and comparatively cheap. Peat in Ireland is running up to the unheard-of price of £2 10s. per ton.—(Through Colliery Guardian.)

GAS FROM PEAT AT HORSENS, DENMARK.

By. J. Qvist.

(J. Gasbeleucht, 1918, Vol. 61, p. 193). The shortage of coal in 1917 necessitated the carbonization of wood and peat, the latter after a certain degree of drying in stacks. Horizontal hand-fired retorts were used and a certain amount of coal was carbonized, but separately from the substitutes. The charge of wood or peat was 55-60 kilos. per retort and the make of gas 30 cub. metres per 100 kilos. Trouble occurred owing to accumulations of pitch in the hydraulic main. The gas contained 23-25% CO_2 and had a gross calorific value of 3700-4000 kilogram calories per cub. metre. On distribution of the gas there was an increase of trouble due to naphthalene stoppage. The yield of ammonia was small but the admixture of a proportion of coal gas sufficed to neutralize the acetic acid present. The air supply of gas appliances required adjustment, but apart from an increased consumption the gas behaved satisfactory in most of its applications. The pitch from wood and peat was valueless, but the brown tar found a ready market. The wood charcoal proved to be well adapted to use in suction gas producers. Peat charcoal was less satisfactory, as much of it was small and had to be employed as an indifferent domestic and industrial fuel.

* **Peat in 1917**

By C. C. OSBORN.

Introduction.

Stimulated by the war and by the consequent high price of nitrates, the output of peat in the United States in 1917, both as a direct fertilizer and as a culture medium for nitrifying organisms, was almost double the quantity produced in any other year in the history of the domestic industry. This unprecedented growth was due to the progress recently made in the application of bacteriology to soil fertilization and to the demand for large crops wherewith to feed both our own people and our Allies. This requirement necessitates the intensive cultivation of the soil, which implies a greater use of fertilizer and a consequent greater production of peat. In fact, the virtual commandeering by the Government for use in the explosives industries of practically all nitrate imported from Chile or produced in this country in retort ovens, makes the peat deposits of the United States one of the few domestic sources of nitrogen that can be converted into plant food at a price that is economical to the farmer. In response to the demand for live stock the producers of stockfood peat also materially increased their output in 1917. In view of these conditions and of the shortage of coal at the end of the year in the Eastern and Central States, the significance of our vast undeveloped peat deposits, pointed out by Davis, Bottomley, and others, is becoming more widely appreciated, so that peat promises soon to take an active part in the industrial progress of the United States.

Peat Industry—General Conditions.

The year 1917 was one of great prosperity for the peat industry of the United States. The quantity of peat produced and sold exceeded the quantity marketed in any preceding year, and, with the exception of the manufacture of peat for use as fuel, all branches of the industry shared in the general prosperity. The most striking development, however, was the greater use made of peat as a culture medium for nitrifying and other bacteria in the manufacture of bacterial fertilizer.

*Reprint from U. S. Geo. Sur.

The total number of individuals and companies engaged in the production of peat in 1917 was 18, an increase of 5 over the number operating in 1916. All the producers that were operating in 1916 except two contributed to the output of peat in 1917, and seven companies that were not represented in 1916 reported commercial production. Many new companies were organized in 1917 but did not complete their plants in time to contribute to the year's output. The plants known to be at work in 1917 were distributed as follows; California 2, Florida 2, Illinois 2, Indiana 1, Massachusetts 1, New Jersey 5, New York 3, Pennsylvania 1, and Virginia 1.

All the producers reported that the demand for peat in 1917 exceeded the supply, and some stated that, owing to railroad embargoes and scarcity of labor, they were unable to fill the orders of their regular customers. Substantially all the peat plants that operated in 1917 made improvements to increase production in 1918.

The prosperity in the peat industry in 1917 was a direct consequence of the increase in the acreage of crops grown in that year, of the intensive cultivation of those crops, and of the shortage and high price of inorganic fertilizers. The demand for peat fertilizer is steadily increasing as its value becomes better appreciated and the outlook for still greater expansion in all branches of the peat industry is good. The prices for peat products averaged higher in 1917 than in 1916.

Production—Raw Peat.

The quantity of raw peat marketed in the United States in 1917 was 97,363 short tons, a quantity greater by 44,857 tons, or about 85 per cent, than the output in 1916, and by 42,220 tons, or nearly 77 per cent, than the record output of 55,143 tons in 1911.

Nearly all producers of raw peat in the United States refine their entire output, and it was therefore impossible to determine accurately the value of the raw product. However, the average price for all refined products received at the point of consumption was a little more than \$7.29 a ton, and the gross market value was \$709,900, a gain of 26 cents in average price per ton and of \$340,796, or approximately 92 per cent, in gross market value.

JOURNAL OF THE AMERICAN PEAT SOCIETY

PEAT PRODUCED IN THE UNITED STATES, 1908-1917.

Year.	Quantity (short tons)	Value
1908.....	*24,800	*\$133,000
1909.....	29,167	127,042
1910.....	37,024	140,209
1911.....	55,143	272,114
1912.....	47,380	228,572
1913.....	33,260	\$197,200
1914.....	47,093	309,692
1915.....	42,284	288,537
1916.....	52,506	369,104
1917.....	97,363	709,900

*Estimated.

Refined Products—Fertilizer and Fertilizer Filler.

The manufacture of fertilizer is the largest and most successful industry based on peat in the United States. All the individuals and companies that produced peat in 1917 also manufactured peat fertilizer or fertilizer filler, the output of which, as reported to the United States Geological Survey, amounted to 92,263 short tons. Compared with the production of 1916 this quantity is greater by 44,157 tons, or almost 92 per cent, and exceeds the record established in 1911 by 40,530 tons, or about 78 per cent.

The average price received for the material in 1917 at the point of consumption was \$7.14 a ton, a gain of 14 cents a ton over the average price received in 1916. These gains in output and price were sufficient to make the total market value of the production in 1917, amounting to \$658,500, exceed the value of the output in 1916 by \$322,496, or nearly 96 per cent.

Of the total quantity of peat fertilizer and fertilizer filler marketed in 1917, 26,850 short tons, or about 29 per cent of the entire output, valued at \$256,000, was bacterized.

The notable growth of the peat fertilizer industry in 1917 was due mainly to the increase in the acreage of land tilled, the more intensive cultivation of crops, the lack of commercial fertilizer, and the application of bacteriology to soil fertilization. The condition of the commercial fertilizer market, the unprecedented expansion of the peat industry in 1917, and the good results reported by many who used peat for the cultivation of crops in that year warrant the expectation that the peat industry will soon occupy a high position among the mineral industries of the United States.

PEAT FERTILIZER AND FERTILIZER MARKETING IN THE UNITED STATES, 1908-1917.

Year.	Quantity (short tons)	Value
1908.....	23,000	*\$121,210
1909.....	26,768	118,891
1910.....	37,024	140,209
1911.....	51,733	257,204
1912.....	41,080	186,022
1913.....	28,460	169,600
1914.....	37,729	249,899
1915.....	38,304	258,447
1916.....	48,106	336,004
1917.....	92,263	658,500

*Estimated.

Stock Food.

The quantity of peat used in compounding stock feed in the United States in 1917 was 5,100 short tons, valued at \$51,400, or an average price of \$10.08 a ton. Compared with 1916, the output in 1917 was greater by 800 tons, or almost 19 per cent, and the value was greater by \$19,150, or about 59 per cent. Three peat producers manufactured stock food in 1917, compared with two in 1916.

PEAT USED IN COMPOUNDING STOCK FOOD IN THE UNITED STATES, 1912-1917.

Year.	Quantity (short tons)	Value
1912.....	3,000	\$18,000
1913.....	4,800	27,600
1914.....	(*)	(*)
1915.....	3,980	30,090
1916.....	4,300	32,250
1917.....	5,100	51,400

*Not available.

Fuel.

Although small quantities of peat were prepared for experimental purposes and by the owners of small bogs for home use, no peat fuel was produced on a commercial scale in the United States in 1917. The one operator that reported a small

output in 1916 was inactive in 1917, and the company experimenting with the Herbein briquetting process, mentioned by the Survey in 1916,¹ has not yet reached the stage of commercial production.

The construction of several peat-fuel plants was begun in 1917 in the New England States, where the recent coal shortage was felt keenly, but they were not completed in time to operate in that year. It is probable that the year 1918 will record the resumption of the production of peat fuel in this country. One of the difficulties reported by persons interested in this enterprise was the lack of peat-fuel machinery, which is scarce in the United States.

Other Uses.

Small quantities of peat and peat moss of unknown value were also produced and used in 1917 in the manufacture of paper, for stable litter, packing material, and insulation, but as this output was used largely for experimental purposes it was not included in the statistics of production for the year.

Imports.

PEAT LITTER IMPORTED FOR CONSUMPTION IN THE UNITED STATES, 1913-1917.

Year.	Quantity (short tons)	price per ton	Value
1913.....	10,983	\$5.07	\$55,719
1914.....	9,921	5.80	57,542
1915.....	7,514	6.41	48,142
1916.....	3,042	9.16	27,859
1917.....	506	9.81	4,966

The foregoing table indicates that all the peat imported by consumers in the United States consists of litter, known to the trade as "peat moss." In 1917 it was only 506 short tons, valued at \$4,966, an increase in value per ton over 1916 of \$0.65, but a decrease in total quantity of 2,536 tons. In previous years peat litter was imported into this country from Holland and Germany, but in 1917 it was entered from Canada. It is apparent that imports of peat litter have been rapidly declining in recent years. This condition is not due to a decrease in the demand for peat litter but is doubtless chargeable to the situation brought about by the war.

¹Turp, J. S., Peat: U. S. Geol. Survey Mineral Resources, 1915, pt. 2. p. 1028, 1616.

Consumption.

The succeeding comparative table has been compiled from reports of sales filed by manufacturers of peat products and from the records of the Bureau of Foreign and Domestic Commerce.

**PEAT PRODUCTS MANUFACTURED, IMPORTED, AND
SOLD IN THE UNITED STATES IN 1916 AND 1917.**

Kind of Product.	——Production——	
	Quantity (short tons)	Value
1916.		
Fertilizer and fertilizer filler.....	48,106	\$336,004
Stock food	4,300	32,250
Miscellaneous*	100	850
Moss litter .....	.....	.....
	52,506	369,104
1917.		
Fertilizer and fertilizer filler.....	92,263	658,500
Stock food	5,100	51,400
Moss litter .....	.....	.....
	97,363	709,900
Kind of Product.	——Imports——	
	Quantity (short tons)	Value
1916.		
Fertilizer and fertilizer filler.....	.....	.....
Stock food .....	.....	.....
Miscellaneous*	100	850
Moss litter	3,042	27,859

1917.		
Fertilizer and fertilizer filler.....	.....	.....
Stock food .....	.....	.....
Moss litter	506	4,966
	506	4,966

	Sales	
1916.		
Fertilizer and fertilizer filler.....	48,106	\$336,004
Stock food	4,300	32,250
Miscellaneous*	100	850
Moss litter	3,042	27,859
	55,548	396,963
1917.		
Fertilizer and Fertilizer filler.....	92,263	658,500
Stock food	5,100	51,400
Moss litter	506	4,966
	97,869	714,866

*Includes peat used by florists and for fuel.

Occurrence, Properties, and Uses.

Owing to the increased interest in the larger use of peat, indicated by the increasing number of requests received by the United States Geological Survey for information on the subject, and in order that the public may be fully informed of the value of peat as a raw material upon which many important industries may be based, a brief statement of the occurrence, properties, and uses of peat is given herewith. Much of the information presented is based upon the work of Davis, Shaler, Bottomley, and others, and liberal use has been made of the results of their experiments.

Definition.

Peat is a dark-brown or black residuum produced by the partial decomposition and disintegration of mosses, sedges, trees, and other plants that grow in marshes and like wet places. It may be identified as the dark-colored soil found in bogs and swamps, commonly called muck, although technically the term "muck" should be restricted to such decayed vegetable matter as is impure and contains too much ash to burn readily. True peat consists principally of carbon, hydrogen, and oxygen, in varying proportions, and because of its high carbon content, it will ignite and burn freely when dry. If plant refuse is exposed to the air for long periods of time true peat is not formed, but advanced decomposition takes place and results in the formation of humus or in the disappearance of all the plant material except the ash or mineral part.

Conditions of Formation.

The accumulation of peat is dependent on conditions favorable to the profuse growth of water-loving plants and the escape of their remains from complete decomposition and disintegration by the action of fungi and bacteria. Hence it is clear that climate and topography govern the formation of this material. If the land surface contains numerous depressions or poorly drained areas in which water may collect and stand permanently, and if the temperature of the air and the soil is low in summer and the relative humidity of the air is high enough to prevent rapid evaporation, peat-forming plants will flourish. In the process of growth plants form cellulose, the chief constituent of plant tissue, which they derive from gases taken from the air and minerals supplied through their roots. If, after maturity, the remains of a plant fall on dry earth, the carbon in the cellulose is released as carbon dioxide and the minerals are returned to the soil, and in a relatively short time the dead vegetable matter disappears. When, however, vegetation falls into water or on soil saturated with moisture it undergoes a different change. The water protects it from the attacks of fungi and bacteria, a large proportion of the carbon is retained, decay is arrested, and chemical changes blacken and soften the vegetable matter. The material may remain in this state indefinitely unless the land surface rises and decomposition again begins, or unless the surface subsides and the material is buried beneath later deposits and becomes a coal bed.

There are two kinds of peat deposits—the lake bog, in which the dead vegetable matter accumulates below water level, and the climbing bog, in which the level of moisture may never rise above the surface of the peat but is progressively elevated as the plant remains collect. In the lake bog, which is the more common kind in this country, the peat is usually formed in a lake or marsh by the successive growth and decay of algae, cryptogamic mosses, pond weeds and lilies, bulrushes, sedges, grasses, shrubs, and sphagnum moss. The climbing bog is found on level areas or gentle slopes in regions of heavy rainfall, where the drainage is so greatly interrupted that the soil becomes permanently saturated with water and is generally built up by sedges, herbs, sphagnum, shrubs of the heath family, and certain trees.

Distribution and Quantity.

The most extensive peat deposits in the United States are found in a region which lies east of the 97th meridian and north of an irregular line drawn eastward through the north.

ern sections of Iowa, Illinois, Indiana, Ohio, Pennsylvania, and New Jersey and approximately includes the area covered by the Wisconsin or last glacial drift. Many workable peat beds occur also in areas extending 25 to 50 miles inland on the Atlantic coast from New Jersey to southern Florida and along the gulf coast to the Mexican boundary, and there are a few workable beds of peat in the Pacific Coast States.

The areas of peat accumulation in this country may therefore be roughly assigned to two regions, the northern and the coastal, and this subdivision, though mainly geographic, expresses in some degree differences in manner of formation and in the quality of the peat.

The northern region includes the New England States, Minnesota, Wisconsin, Michigan, and New York, and the northern sections of Iowa, Illinois, Indiana, Ohio and Pennsylvania. This region is characterized by the presence of numerous small lakes and marshes and by relatively low temperature and high humidity and the peat deposits are generally of the lake-bog kind. Moss, sedge, and grass peat are abundant, and much sphagnum is found growing on bogs in Maine and in the northern counties of Minnesota, Wisconsin, Michigan and northeastern Pennsylvania. In New England there are many climbing bogs, but the deepest and most extensive deposits are of the lake-bog kind and lie east of the Berkshire Hills and the Green Mountains.

The coastal region embraces the eastern sections of New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia, all of Florida, the southern districts of Alabama, Mississippi, and Louisiana, and coastal Texas. The nearness of the ocean causes heavy rainfall and high relative humidity in this region, and the deposits are found in drowned valleys and lagoons formed by the gradual subsidence of the Coastal Plain and by wave action, and on flat, imperfectly drained areas farther inland. It is typified by many fresh and salt water marshes, in which the deposits have been formed largely by marsh grasses, and other plants, some of which tolerate salt water around their roots. On the Gulf coast, owing to the hot climate, dead vegetation decays rapidly, and as the peat therefore accumulates slowly it contains much ash. The most extensive peat deposits in the coastal region occur in Florida.

The known workable peat beds of the Pacific coast are found in Orange and Los Angeles counties, California, and in the basins of several of the lakes and rivers of Washington and Oregon; but on account of the rapid run-off in this section of

the country peat deposits of commercial extent are comparatively rare and are not of sufficient importance for the section to be considered a major region.

Although there are a few peat deposits on the New England coast that are related in origin and composition to those classed in the coastal region, by far the most numerous bogs of the Northwestern States are of the glacial-like kind, and the region as a whole should be so considered in a classification of the major areas of peat accumulation.

Although it is impossible with the data at hand to determine accurately the quantity of peat in the United States, it is estimated² that 11,000 square miles of swamp land contains peat beds of good quality and that the total available peat suitable for commercial use in these deposits would amount to more than 12,000,000,000 tons.

Physical and Chemical Properties.

Native peat consists chiefly of decayed vegetation and water in varying proportions, the usual ratio being 10 per cent of the former to 90 per cent of the latter. In specific gravity it ranges from 0.1 to 1.06 and in weight from 7 to 65 pounds per cubic foot. Aside from its high water content this substance is extremely variable, scarcely any two deposits containing material that is exactly similar in physical properties. This diversity is due to many factors, the most important of which are the great variety of plants from which the peat is formed, different in climate, in the ages of the deposits, in water level, and in quantity of sediment deposited during the accumulation of the peat.

Peat ranges in color from light yellow through various shades of brown to jet-black, the color representing in a measure the degree of decomposition. If the deposit is new or has been well protected from the air the peat is usually light yellow or brown; thoroughly decomposed, humified peat is jet-black. Upon drying in the air most peats become brighter in color, except the very light varieties, which usually change to dark brown or black after being macerated and dried. Peat that is red, gray, or white in spots or feels very gritty when crushed between the teeth contains too much inorganic mineral for commercial use as a fuel.

The texture of peat depends upon the kinds of plants from which it was formed and the physical conditions under which it accumulated. Peat formed from algae and mosses is fine grained and comparatively homogeneous, whereas peat pro-

²Davis, C. A., Peat resources of the United States, exclusive of Alaska: U. S. Geol. Survey Bull. 394, pp. 65-66, 1909.

duced by the decay of grasslike or woody plants will generally be found fibrous and poorly decomposed unless very old. Peat formed by the decomposition of shrubs and trees is woody in structure. Dead vegetation of any kind that is exposed for long periods to the free action of fungi and bacteria will become thoroughly disintegrated and of fine texture. In moist areas like New England and the vicinity of the Great Lakes peat is generally less variable in texture than it is in areas of alternate drought and heavy rainfall, such as are found farther west. Peat that accumulates in river valleys and lakes whose water contains much sediment is usually too impure and contains too much ash for commercial use.

The following classifications of peats by physical characteristics includes all types found in the United States:

(a) **Turfy Peat.**—Consisting of slightly decomposed mosses and other peat-producing plants, having a yellow or yellowish-brown color, very soft, spongy, and elastic; specific gravity, 0.11 to 0.26, the full English cubic foot weighing from 7 to 16 pounds.

(b) **Fibrous Peat.**—Unripe peat which is brown or black in color, less elastic than turf peat, the fibers either of moss, grass, roots, leaves, or wood, distinguishable by the eye, but brittle and easily broken; specific gravity, 0.24 to 0.67, the full cubic foot weighing, accordingly, from 15 to 42 pounds.

(c) **Earthy Peat.**—Nearly or altogether destitute of fibrous structure, drying to earthlike masses which break with more or less difficulty, giving lusterless surfaces of fracture; specific gravity, 0.41 to 0.90, the full cubic foot weighing from 25 to 56 pounds.

(d) **Pitchy Peat.**—Dense; when dry, hard; often resisting the blows of a hammer, breaking with a smooth, sometimes lustrous fracture into sharp-angled pieces; specific gravity, 0.62 to 1.03, the full cubic foot weighing from 38 to 65 pounds.

Peat consists of carbon, hydrogen, oxygen, and relatively small quantities of nitrogen. Although the exact atomic relations of its principal elements are not known and probably are not constant, the formula $C_{62}H_{72}O_{24}$ is typical. The composition of peat is illustrated by the following analysis (ash omitted):

COMPOSITION OF PEAT.

Carbon	59.50
Hydrogen	5.50
Oxygen	33.00
Nitrogen	2.00

3Johnson, S. W., Peat and its uses, pp. 95-96, New York, 1866.

The ash found in native peat, which renders it more or less impure, constitutes from 3 to 30 per cent of its dry weight and is traceable either to the plant cells or to the mineral carried in suspension or solution by the water in which the peat formed. The inorganic impurities of peat are silica, alumina, iron oxide, magnesia, lime, soda, potash, sulphuric acid, chlorine, and phosphoric acid. If the ash content exceeds 8 per cent, it is due to the mineral matter in the water that covered the peat during formation, and it usually consists of silica in the form of sand or silt or of alumina and silica in the form of clay. Mineral constituents other than silica and alumina in excess of 8 per cent are not common in peat and where found may be traced to the local water supply. If the inorganic impurities of decayed vegetation are much in excess of 30 per cent, the material should be classed as muck rather than peat.

Uses.

The uses of peat are numerous and varied. In the countries of northern Europe it is used for fuel and as the basis for many manufacturing industries. Gas, charcoal, coke, and a number of valuable by-products are produced from it. Owing to the scarcity of raw materials in Europe peat and peat moss are also employed as substitutes for absorbent cotton in the preparation of surgical dressings, for wood, and for cotton and woolen cloth.

In the United States peat is utilized chiefly as fertilizer and fertilizer filler, as stable litter, and as an absorbent for the uncrystallized residues of beet and cane sugar refineries in the manufacture of stock feed.

Peat as Fuel—General Features.

Peat, because of its high carbon content and the fact that it will ignite and burn freely when dry, yielding an intense heat, is used for fuel in countries where the coal supply is below normal requirement. In Europe between 15,000,000 and 20,000,000 tons of hand-cut and machine peat are consumed annually. The hand-cut peat is produced by the peasants for domestic use and the machine peat is sold in the form of blocks for both domestic and industrial use. Many attempts have been made both in Europe and in the United States to manufacture peat briquets for commercial use, but, though these are more efficient than hand-cut or machine peat, the process, on account of the high cost of production, has never advanced beyond the experimental stage, so far as the United States Geological Survey is aware.

Peat in an undrained bog contains about 90 per cent of

water, which must be reduced to 30 per cent before the peat can be used for fuel. By thoroughly draining the deposit approximately 10 per cent of the original water contained in the peat may be eliminated, but the remainder, which is held in the microscopic plant cells and minute intercellular spaces, cannot be reduced below 70 per cent without drying in the open air or in a heated chamber. However, artificial drying requires the expenditure of so much heat in comparison with the heat obtainable from the fuel prepared by this method that it has not proved commercially feasible.

The value of a given deposit of peat as a source of fuel is dependent upon many factors, most important of which are degree of decomposition, heating value, and ash content. Coarse-textured fibrous peat is inferior for fuel to the black, compact, thoroughly decomposed kind, unless the latter contains too large a proportion of ash. The maximum quantity of ash that is usually considered allowable in peat for commercial use has been placed between 20 and 25 per cent, but if it exceeds 20 per cent of the total dry weight the peat is scarcely worth the labor of production.

The following table shows the calorific value of peat as used commercially compared with other mineral fuels:

COMPARATIVE CALORIFIC VALUE OF PEAT AND OTHER FUELS.

	British thermal units
Wood	5,760
Air-dried cut peat	6,840
Air-dried machine peat	7,290
Lignite	7,500
Bituminous coal	14,000
Anthracite	13,000

Cut peat is bulky, is easily crushed, and burns rapidly with considerable waste. It is superior to wood in heating value but is unfitted for commercial use. However, despite the disadvantages of cut peat, machine peat is suitable for both domestic and industrial use, and powdered peat is well adapted for use under steam boilers with forced draft. In calorific value a ton of machine peat is equal to about 1.3 tons of wood, 0.5 ton of good bituminous coal, and 0.6 ton of anthracite. It is clean to handle and burns freely, yielding an intense heat and producing no soot or other objectionable deposit. For open grates this fuel is nearly ideal, and it is said that peat may be burned in the same stoves as coal and wood. However,

the best results for household use could probably be obtained by burning it in a stove with relatively small grate openings and a restricted draft.

Peat Fuel in the United States.

Although in Europe between 15,000,000 and 20,000,000 tons of this fuel are produced and consumed annually in generating heat and power, in the United States, because of the abundance in normal times of coal, which is more efficient and can be cheaply prepared and more readily transported to the consumer, only small quantities of peat fuel have been produced, and the interest shown in previous years in its possibilities has been largely scientific and experimental. The attempts that have heretofore been made in this country to produce peat fuel on a commercial scale have not been successful, but the failure appears to have been due not to a lack of market for the product but to the lack of sufficient capital, to the inexperience of operators, and to preventable engineering errors. It is said that air-dried machine peat can be produced in the United States at a cost ranging from 75 cents to \$2.50 a ton, the exact figure depending on the size and efficiency of the plant, and it is believed that in some parts of the country it could successfully compete with other fuels for both domestic and industrial use. In many places where peat fuel has been used in this country it has proved very satisfactory and has found ready sale as fast as produced.

In recent years the increasing cost of producing coal and the failure of the operators to keep pace with the ever-expanding demand have led to a general advance in price. This condition, aggravated by an appreciable reduction in the visible coal supply and the rapid exhaustion of our forests, has made a marked impression upon economists and others and has created a desire to conserve these materials by investigating and substituting other fuels and sources of power wherever they can be more economically used.

Van Hise⁴ in urging the conservation of our wood and coal reserves says:

"So far as practicable other products should be substituted for wood. The original forests of the United States contained not less than 850,000,000 acres, having not less than 4,800,000,000 feet of merchantable saw timber. This was our magnificent heritage. The United States as a Nation has existed a century and a quarter, and what have we now? In that brief time approximately one-half of the value of our forests has gone.

⁴Van Hise, C. R., *The conservation of natural resources in the United States*, pp. 210, 256, 359, New York, Macmillan Co., 1910.

"So far as practicable substitutes should be used for coal. Even if all possible economics and substitutes are introduced, the most sanguine can not hope that the supply of fuels will be sufficient to meet the needs of the people for more than a small fraction of the time we look forward to as the life of this Nation."

The shortage of coal in the Eastern and Central States that began toward the end of 1917 has also stimulated a wide interest in the peat deposits of the United States and their potentialities as a source of auxiliary fuel, and from the increasing number of requests received by the United States Geological Survey for information on the subject, it seems that the public is willing to consider seriously the use of peat to prevent a recurrence in some localities of the suffering caused by inadequate fuel supplies last winter. The lack of coal in many European countries that has existed since the beginning of the war is being supplied in part by the increased use of peat, and there is no reason why the United States should not utilize its vast deposits of this fuel.

It will be noted that in the northern peat region there are no known coal fields, except in small sections, notably in Michigan, and that the peat deposits are largely confined to States which, because of their cold climate and extensive manufacturing industries, consume large quantities of fuel. In the southern part of the coastal region, although the climate is mild and the demand for fuel relatively small compared with that in the Northern States, there are no local sources of other mineral fuels. The preparation and storage of peat fuel taken from these deposits would not only increase the local fuel supply and in many communities prevent a recurrence of the suffering caused by the coal shortage in 1917, but would release railroad cars which will be vitally needed for other purposes during the war.

Although peat fuel may not be extensively produced in the United States in normal times as long as there is an abundant supply of coal, except possibly in localities where conditions are peculiarly favorable, it has great potential value as a source of heat and power and may be utilized to conserve our reserves of coal and wood and also, during economic and industrial crises, may be used locally in some States to prevent a fuel shortage.

Methods of Preparation.

Cut Peat.—In the United States the season for drying peat begins about April 15, or as soon as the frost is out of the ground, and ends approximately September 15, except in the southern peat region, where it is somewhat longer. Peat in-

tended for domestic use may be economically prepared by the owners of small deposits either by hand or by small-capacity peat machines. The heating value and ash content of prospective peat fuel for home consumption may be determined by a simple practical test. A typical sample should be taken from the bog, thoroughly macerated, dried, and weighed. If when burned in an ordinary heating stove the heat generated is almost equal to that produced by ordinary bituminous coal and if after complete combustion the weight of the accumulated ash does not exceed 20 per cent of the weight of the dry peat put into the stove, its usefulness as domestic fuel is established.

For home use the preparation of peat by hand, which is the method so widely used in Ireland, seems most practicable for the owners of small deposits in the United States. Before this process can be used the deposit must be thoroughly drained and cleared and the turf removed from its surface. Bogs of the built-up type, that is, those which were formed by the deposition of the remains of plants that grew near the ground-water level, can usually be drained to the bottom by a simple system of surface ditches. Lake bogs in which deposits have accumulated below a permanent water level can not generally be drained far below the surface of the peat without incurring great expense, and hence are not so well adapted as built-up bogs to hand digging. However, many lake bogs in the northern peat region, where most of the marshes in which this material has accumulated were formed by the Wisconsin or last glacial drift, may be sufficiently drained for peat recovery by means of a short drainage canal connecting the edge of the basin at the lowest level with an adjacent stream.

After the surface of the bog has been cleared the peat is dug in brick form with a special tool called a slane. This instrument, which can be made by a blacksmith, consists of a narrow spade with a sharp steel lug welded on one side and at right angles to the edge of the blade. The blocks range from 8 to 10 inches in length, from 4 to 7 inches in width, and from 3 to 6 inches in thickness, depending on the size of the slane. As they are dug they should be removed to the drying grounds or placed on covered racks. At the end of about four weeks, during which they should be frequently turned until the moisture content is reduced to about 30 per cent, the blocks are usually ready for storage. As cut peat absorbs water rapidly, extreme care should be taken to protect the dry blocks from rainfall.

Machine Peat.—If it is desired to produce peat fuel of better quality and in larger quantities than is possible by hand, the machine method should be adopted. This process is, so far

as known by the United States Geological Survey, the only one that has proved commercially successful in Europe. The machinery for a small plant is simple and easily operated. It consists essentially of an excavator and a macerator. The steam shovel could be used for digging peat from drained deposits, and the dipper dredge is admirably adapted to removing this mineral from deposits which can not be economically drained. The purpose of the macerator is to grind the constituents of the wet peat into a homogeneous pasty mass which may be shaped into compact blocks. In principle and form the latest types of peat machines are similar to the pug mill or grinding machine for plastic clay. Many of the experimental plants in the United States have used brickmaker's pug mills very slightly changed to grind peat and have found them well suited for the purpose. After being thoroughly macerated the peat is shaped into compact blocks as it comes from the machine or is spread in a layer from 8 to 12 inches thick on the drying grounds, and the bricks are marked off by hand as the spreading proceeds. When partly dry the bricks are loosely stacked or placed on drying racks and thereafter handled in the same manner as cut peat.

Machine peat which is allowed to dry slowly contracts into a dense mass covered by a gelatinous skinlike substance called hydrocellulose. After the moisture has been reduced to about 25 per cent this coating renders the machine peat impervious to water, even when immersed.

A specially designed and constructed machine is used for the commercial production of peat fuel. Such a machine consists of a receiving hopper attached to a vertical or horizontal cast-iron body, in which revolve one or two knife-armed shafts. These shafts are also provided with spirally arranged flanges for moving the peat to the grinding knives and advancing it to the device for cutting the peat pulp into bricks of uniform length as it issues from the orifice of the machine. The principal types of peat machines of modern construction are fully described and illustrated in a publication of the Canada Department of Mines.⁵

Powdered Peat.—If raw peat is allowed to lie in heaps until natural drainage and evaporation has reduced the moisture content to about 50 per cent, it may be prepared for use under steam boilers by driving off about half of the remaining moisture with waste heat from flues and pulverizing the resulting material. According to E. A. Beals, of Hartford, Conn., who has been experimenting with this process, the powdered

⁵Nystrom, E., *Peat and lignite; their manufacture and uses in Europe*, Canada Dept. Mines, Mines Branch, 1908.

peat may then be blown with compressed air into the furnace, where, by means of a forced draft, ignition is almost instantaneous, and instead of burning on the grate, the peat forms a gas which gives a uniform fire throughout the entire combustion chamber.

Good peat thus treated, when burned in furnaces designed to give the most complete and efficient combustion, is said to given nearly as much energy in the form of live steam as the same weight of produced coal.

Peat powder may also be prepared for fuel by pulverizing machine peat blocks after they have been air dried to about 40 per cent of moisture and then screening and heating the material thus obtained in rotary driers until it contains about 15 per cent of moisture. However, this process is so expensive that it is doubtful whether peat so prepared could successfully compete with powdered coal.

According to reported tests in this country powdered peat has great possibilities, not only for boiler firing but for metallurgic work and for use in cement and other kinds of kilns in which powdered coal has been successfully burned.

Producer Gas and By-Products.—Peat consumed in a properly designed gas producer yields gas of good quality and in abundant quantity in comparison with the yield from coal, and also many valuable by-products. This is perhaps the most effective utilization of peat fuel for generating heat and power, because peat that is to be used in this way does not need to be so carefully prepared nor so thoroughly dried as peat that is to be consumed for domestic purposes or under steam boilers. Gas-producing plants using peat fuel are operated in England, Ireland, Germany, Sweden, Italy, and Russia; but in the United States, although experiments have been made, no gas-producing plants are operated with peat.

Analyses of the peats of the United States show that they are very rich in combined nitrogen, from 70 to 85 per cent of which—a proportion that in some peats amounts to more than 2 per cent of their dry weight—could be recovered in the form of ammonium sulphate in by-product gas-producing plants operated with peat.

Peat in Agriculture.—Drained Peat Land.

Large areas of land in the United States overlain with peat beds less than 5 feet deep could be profitably drained and utilized for the cultivation of crops. There is approximately 15,000,000 acres of peat and muck land supporting a growth of shrubs, tamarack, white cedar, birch, water maple, gum, and cypress in the eastern section of this country, and only about

750,000 acres, or 5 per cent of the total area, has been reclaimed for agricultural purposes. Peaty soils that have been drained, cleared, and freely exposed to the air by plowing are well adapted to the production of vetch, buckwheat, corn, potatoes, carrots, the cranberry, and improved forms of blueberry. When properly treated with potash salts or with lime they are neutralized or made slightly alkaline and will then yield large quantities of red clover, wheat, oats and other alkaline-soil crops. Many regions in the United States are underlain by beds of marl, consisting chiefly of shells of lime carbonate deposited by organisms and later covered by peat in land-locked bays, or of shells and lime carbonate precipitated through the agency of blue-green algae and stoneworts (*Chara*) in bodies of fresh water, in which peat has subsequently accumulated. In these areas the land could be economically treated with lime from these deposits and the yield of alkaline soil crops might thus be materially increased. However, the greatest values derived from the cultivation of peat and muck have arisen from their use as special-crop soils. Cabbage, onions, celery, lettuce, spinach, carrots, beets, turnips, and peppermint are the most valuable crops that are grown on farmed areas of peat and muck. The acreage values of these crops so far surpass those of the general farm crops that the reclamation of any large areas of peat or muck should be undertaken with the special object of their production. For the profitable sale of these special crops it is desirable that such areas of peat and muck as are easily accessible to large city markets or to rapid transportation should first be reclaimed.

Fertilizer and Fertilizer Filler.

Peat has long been used in fertilizing the soil, having been either applied as a direct fertilizer or used as a filler for commercial fertilizer. Analyses of the peats of the United States show an average nitrogen content of about 2 per cent, a proportion somewhat higher than that found in some commercial fertilizers. The value of peat in soil fertilization is found in its nitrogen content and in the beneficial mechanical effect it produces upon certain lands. Black, thoroughly decomposed peats are most satisfactory for fertilizer, as such peats are generally heavier and more compact and contain more nitrogen and less fibrous material than the brown types.

Davis thus briefly describes the process by which peat fertilizer is prepared:⁶

"The processes of preparing peat for fertilizer are compar-

⁶Davis, C. A., Peat: U. S. Geol. Survey Mineral Resources, 1914, pt. 2. pp. 382-383, 1915.

atively simple. The bog is drained thoroughly, and the surface layers are carefully plowed and cultivated for one or more seasons before digging begins. The peat is prepared for sale by reducing it to the state of a powder containing about 10 per cent of moisture. When an area is considered ready for gathering the peat the surface is repeatedly harrowed either by ordinary harrows or by special machinery for the purpose of drying the surface layers as much as possible. When sufficiently dry the harrowed peat is scraped into windrows and loaded on tram cars, which, in the larger plants, are drawn to the drying plant by small locomotives operated by electricity or gasoline. The unloading is done from a trestle over the stock pile, from which the peat is elevated as needed to the inlet hoppers of large rotary cylindrical driers. The driers used are of the directly heated single-tube type—that is, they consist of a single shell of boiler iron, with a large furnace at one end and a settling chamber, from which the smokestack or chimney arises, at the other. The cylinder is slightly inclined from the inlet to the outlet end and is revolved on its long axis by mechanical means. Iron flange, running spirally the length of the inside of the cylinder, raise the peat to the top of the tube and drop it to the bottom through the heated air and gases, as these pass from furnace to smokestack, and at the same time move it steadily forward to the outlet, where it is automatically discharged. Usually a fan blower or an exhaust fan increases the draft through the drier, and this can be regulated to meet the requirements of the peat. After the peat has passed through the drier it is elevated by mechanical conveyers of considerable length to permit proper cooling, screened to remove coarse and lumpy material that has not been completely disintegrated in drying, and immediately shipped or stored in fireproof storage bins. * * * When the peat is to be applied directly to the soil as a source of humus and of organic nitrogen, the drying is not carried so far.”

Bacterized peat is said to be an even more prolific source of soluble nitrates than the crude material. A culture bed of peat, if treated with a dilute solution of ammonium sulphate and then inoculated with nitrifying organisms, is said to yield after one treatment 0.82 per cent of nitrates, and after repeated treatment about 4 per cent. It has not yet been shown that this process is adapted to the production of nitrates on a commercial scale, but in view of the rare occurrence and present shortage of these salts, which are so essential to agriculture, the process strongly invites further and larger experiment. If the only change effected, however, is to convert to a nitrate

the nitrogen supplied to the peat in the ammonium sulphate, the value of the process is questionable.

A more practicable method of increasing the nitrogen content of soils by means of peat is proposed by Bottomley.⁷ It is well known that if peat is exposed to the air for about two years it is neutralized by the formation of ammonia, and a large proportion of the insoluble material is converted into food available for plant life. By inoculating the peat with aerobic bacteria it is found possible greatly to accelerate this change and to increase materially the quantity of plant food. The problem, however, was not to discover a fertilizer, but to find a medium in which nitrogen-fixing organisms could be cultivated and placed on the soil. This medium is found in the peat treated with aerobic bacteria. To prepare it for inoculation the peat is kept moist at a temperature of 26° C. for about a week. Steam is then forced through it to insure that all organisms, bacterial or otherwise, are destroyed, and the result is a sterile medium, neutral or slightly alkaline, suitable for the cultivation of plants or of nitrifying bacteria. The sterilized peat is then inoculated with a mixed culture of *Bacillus radicicola* and *Azotobacter chroococcum*, which multiply rapidly and soon permeate the entire culture bed. After complete saturation the bacterial growth is arrested by drying the peat, and it is then ready for use. It is reported that the bacteria in this material enrich the soil to which they are applied by extracting nitrogen from the air and converting it into soluble plant food and that, owing to continuous bacterial action, frequent subsequent treatment is unnecessary.

Still further progress in the application of bacteriology to soil fertilization has recently been reported by Earp-Thomas, of Richmond, Va. According to his process the peat is mixed with tricalcium phosphate and used as a culture medium for nitrifying the other bacteria which produce phosphorus compounds and which, when applied to the soil, react upon and free its natural potash content from insoluble chemical combinations.

Bacterized peat is being used for fertilizer in England with varying degrees of success. In the United States commercial quantities have been manufactured and sold, and it is reported that crops grown upon soil enriched by it yielded a much greater output than could be obtained from the same land treated with commercial fertilizer.

⁷Knox, G. D., *The spirit of the soil*, 242 pp., 17 figs., London, Constable & Co. (Ltd.), 1916.

Stock Food.

Black, humified peat is used both in Europe and in the United States for compounding stock food. The method of preparing the peat is substantially the same as for fertilizer. After being air-dried and partially carbonized the peat is screened and reduced to a powder containing about 10 per cent of moisture. The powdered peat acts as an absorbent for the uncrystallized residues from beet and cane sugar refining, which, because of their viscosity, are otherwise difficult to feed. This valuable food material may thus be economically fed to cattle and other live stock without causing gastric disorders. It is said that the peat also stimulates the digestive organs, contributes proteid substance, and is an excellent substitute for charcoal. Charred dried peat is also frequently used as an ingredient of poultry and other commercial stock feed. In European countries peat mull and fiber prepared from moss and sedge peat are used as the bases for stock feed.

Absorbent and Disinfectant.

Peat mull may be profitably employed as an absorbent of the valuable nitrogenous liquids of stables, which are ordinarily wasted. When so used it not only absorbs liquids but checks decomposition and absorbs gases, so that it should be an effective deodorizer and disinfectant. For this use it is superior to lime, ashes, and some of the more expensive disinfectants, and it is a nearly ideal material for use in earth closets and other receptacles for moist waste organic matter. Peat mull and litter are successfully used in this country as bedding for stock.

Peat as an Antiseptic.

Certain varieties of sphagnum or peat moss are so antiseptic and absorbent that they are widely used as a substitute for medicated cotton in dressing cuts and wounds. This fact was first recognized in the British Isles, but the reputation of sphagnum as a surgical dressing soon spread to the European Continent, where it is now extensively utilized by the French Red Cross in the hospitals of Boulogne and elsewhere. It is also reported that sphagnum has been used in Malta, Alexandria, Gallipoli, and Serbia.

It is understood that experimental work with a view to utilizing sphagnum is being done in this country by the American Red Cross.

In some ways sphagnum is superior to cotton for surgical dressings. It is more resilient, lighter, and cooler, and has inherent antiseptic properties that can be given to cotton only by

special treatment. Native sphagnum is about 90 per cent water, and when thoroughly dry it is said to be capable of absorbing moisture to the extent of about 22 times its own weight, whereas cotton absorbs less than 11 times its own weight. In England the long-leaved variety of *Sphagnum cym-bifolium* is in greatest demand for surgical use, but in the United States *Sphagnum papillosum* is said to be the best.

According to E. K. Soper⁸ there are many square miles of sphagnum bog in Oregon and in the northern counties of Minnesota, Wisconsin, and Michigan that would supply material suitable for this purpose. Sphagnum is also abundant in Maine, and some is found in New York and northeastern Pennsylvania. It would not be necessary to incur the expense of excavation, for immense quantities of sphagnum could be taken from the surface of the bogs.

The following quotation⁹ explains briefly the preliminary method of preparing sphagnum for medical use:

"The moss should be picked by hand in strands 6 or 7 inches long without wringing the water from it, and should be so spread on near-by bushes or rocks that the air can have free access to it from both above and below. When so arranged it bleaches white and becomes thoroughly dry in a few days. Impurities such as grass, rushes, etc., are then removed, and after being sterilized it is packed in clean cotton bags.

PEAT INDUSTRY IN PRINCIPAL FOREIGN COUNTRIES.

General Conditions.

The shortage of coal and fertilizer that has prevailed in Europe since the war began became acute in 1917 and created an unprecedented demand for peat. Individuals, corporations, and government erected plants for its production. Peat will probably be so widely used in northern Europe before the war ends that even with the resumption of normal conditions a greatly increased demand for it will continue. Prospects for the development of a peat industry of large proportions are therefore very good.

It is estimated¹⁰ that in Europe, exclusive of Russia, there are 212,700 square miles of peat bog. in Russia 70,000 square miles, and in Canada 50,000 square miles. European countries annually consume between 15,000,000 and 20,000,000 tons of peat fuel. Of this quantity Russia produces about 5,000,000;

⁸Official correspondence.

⁹Lay, J. G., Continental substitutes for absorbent cotton: Commerce Repts., No. 216, p 1307, Sept. 15, 1915.

¹⁰Knox, G. D., The spirit of the soil, p. 37, London, Constable & Co. (Ltd.), 1916.

Germany, 3,000,000; Denmark, 1,500,000; Holland, 1,000,000; and Sweden, 1,000,000 tons, and the remainder is manufactured and sold in Norway, the British Isles, Austria-Hungary, France, Switzerland, and Italy. It is apparent, therefore, that peat is a resource vast in extent and that the peat industry is still young.

Russia.

To meet the coal shortage created in Russia by the war a committee was organized in 1915 and given power to regulate the production and price of fuels. Since that time measures have been adopted to stimulate the output of peat and increase its use in the industries. A company capitalized at 9,000,000 rubles was recently organized in Moscow for the production of peat fuel.

Germany.

The depletion of Germany's forests at a comparatively early date, while agriculture was the principal occupation of the people, led to the widespread use of peat in that country, especially among the peasants. Later, after the method of preparing peat had been improved, it was used in Germany for both domestic and industrial purposes, and in recent years improvements in gas-producing plants and gas engines that permit the utilization of low-grade fuels has greatly stimulated the peat industry. Before the war the peasants produced large quantities of sphagnum, which was sold to German chemists and exported to England. Since 1914 German manufacturers have been weaving with a yarn spun from peat moss, shoddy, and Swedish wool a cloth resembling cheviot, which is said to make durable clothing. It is estimated that the peat bogs of Germany cover approximately 5,683,400 acres.

Denmark.

The beneficial effect of the European war on the peat industry of Denmark is shown by the following table based upon data furnished by John Olsen, of Arlington, Mass.:

AIR-DRIED MACHINE PEAT PRODUCED AND CONSUMED IN DENMARK, 1914-1917.

Year	Number of pro- ducers	Quantity (short tons)	Average price per ton	Value
1914 -----	65	95,734	(a)	(a)
1915 -----	69	104,878	\$3.70	\$ 388,191
1916 -----	160	130,605	5.83	761,852
1917 -----	564	438,546	6.99	3,063,414

a Not available.

Producers of hand-cut peat fuel reported an output of 1,002,292 short tons in 1917, but as large quantities manufactured by the owners of small deposits for home consumption were not reported it is impossible to compute accurately the value of hand-cut peat produced in Denmark in that year. The quantity of peat coke produced in 1917 was 220 tons and of peat litter 364 tons; the litter was valued at \$8,019, or an average price per ton of \$22.03. Approximately 131,564 tons of machine peat, or about 30 per cent of the entire output, was used in manufacturing plants, gas-producing plants, locomotives, and steamboats, and the remainder was sold to domestic consumers and to hospitals. It is reported that peat containing 60 per cent of moisture yielded 14,000 cubic feet of gas per metric ton and that Diesel engines were driven with this gas. A basic price of \$8.65 a metric ton for peat fuel having a combined ash and moisture content of not more than 35 per cent was fixed by the Danish Government. A reduction from this figure of 15 cents per ton for each per cent of ash and moisture in excess of 35 was allowed to consumers. Through the Danske Hedeselskab the Government subsidized 225 private peat plants to the extent of 50 per cent of the total cost of each plant, and constructed about 15 miles of narrow-gauge railroad connecting the peat bogs with established routes of transportation.

Holland.

Although the moors of Holland contain more than 100,000,000 tons of peat, even fuel from this source has become scarce and has doubled in price since the war began. The peat industry of that country has greatly expanded in recent years, and although peat is not so scarce as coal, the Dutch Government, on account of the acute fuel shortage, has limited the quantity consumers may purchase and has established a maximum price for peat in order to protect the poor classes from profiteering.

Sweden.

Owing to difficulties in importing coal the directors of the Swedish state railways early in 1916 began a series of experiments with peat powder as locomotive fuel. Two peat experts were selected and preliminary cost data were compiled. The peat used was taken from a large bog located at Hasthagen, about a mile and a half from Vislanda. Comparative tests were made with two locomotives of the same type, one being fired with peat averaging 7,920 British thermal units in calorific value and the other with coal capable of generating 13,030 British thermal units. A hopper was mounted on the tender to hold the peat, from which it was blown through a

pipe into the fire box. It is said that the temperature of the fire box on the peat-burning locomotive averaged $1,670^{\circ}$ C. and that the efficiency of the boiler was 73 per cent, whereas on the coal-burning engine the temperature of the fire box averaged $1,510^{\circ}$ C. and the efficiency of the boiler was 68.8 per cent. The tests proved conclusively that powdered peat could be successfully used as locomotive fuel and several large peat-powder plants costing 350,000 each were immediately erected by the Swedish Government. It is estimated that the Hasthagen fields alone are capable of yielding more than 200,000 tons of powdered peat. All the locomotives on the Falkoping-Nassjo Railroad, a line of 60 miles in length, are burning peat. The cost of producing peat powder for use in locomotives in Sweden is said to be about \$3.91 a metric ton.

It is reported that a process was perfected in Sweden in 1917 for manufacturing cloth from peat moss and that a factory designed to produce it in commercial quantities is planned. The peat cloth is alleged to be durable and cheaper than artificial wool. Clothing made from the material is being worn by the inventor and many others.

Sphagnum was also produced and marketed in Sweden in commercial quantities in 1917.

Norway.

Conditions in Norway in 1917 were decidedly favorable to the expansion of the peat industry. Marketed production of machine peat amounted to approximately 100,000 short tons, an increase of 78,000 tons, or nearly 355 per cent, compared with the output of 22,000 tons in 1916. Large quantities of hand-cut peat were also produced by owners of deposits for consumption in their own homes and were not reported.

According to United States Commerce Reports¹¹ 216 peat fuel machines were in operation in Norway in 1917, compared with 55 in 1916 and 36 in 1914. Among these were two automatic machines, each of which cost \$13,400, has a daily capacity of 30 to 40 tons of fuel, and requires only two men for its operation.

Many new deposits were located, and plants which had been idle for several years resumed operations. A bog estimated to contain 8,000,000 tons of peat was discovered on the island of Smolen in the Romsdalsfjord. Vast deposits are found in the northern part of the country and measures have been taken by the Governments to develop those near Chris-

¹¹Dunlap, M. P., Peat production in Norway: Commerce Repts., August, 1917.

tianssund in order to supply peat to the Norwegian state railways. The marsh known as Store Mose, with an area of 250 acres and an average depth of 15 feet, which has been undeveloped for centuries, was opened in 1917 by the municipality of Stavanger, and in August of that year a local manufacturer was constructing 10 peat-fuel machines.

A company, capitalized at \$268,000, to produce peat fuel by the Rosendahl method was formed in 1917. It is alleged that the product, which resembles English coal, has been tested by both industrial and domestic consumers of fuel in Christiania and found satisfactory. Another company obtained the right to produce peat from a small bog near Naerstrand and installed two peat plants.

The maximum price for peat established by the Norwegian Government was \$5.63 a metric ton.

British Isles.

Ireland.

In Ireland peat has been the only domestic fuel of the common people from the traditional time when that country was deforested. It is one of the essential elements of Irish national life, and in many villages remote from modern routes of transportation hand-cut peat is the only fuel available. The peat fire on the hearth, like the jaunting car, typifies Irish environment, and when the tourist seeks a memento of his visit to that country he usually selects some souvenir carved from the black oak that has lain for centuries protected by strata of peat from the attacks of fungi and bacteria. The production of machine peat in Ireland is also constantly increasing, and the Government is encouraging the industry by appropriating funds to aid in the perfection of new processes.

According to the Statist¹² approximately one-seventh of Ireland's surface, or a little over 3,000,000 acres, is covered with peat bogs, a quantity unequaled in any country of the same size. Three-sevenths of this acreage is located in the mountain districts, and four-sevenths on the plains. As the upland peat contains relatively little ash it is higher in calorific value than that in the flat bogs but is not so deep and is less accessible. Most of the flat bogs are found in the great central plain within an area bounded on the north by a line drawn from Dublin to Sligo and on the south by a line extending from Wicklow to Galway. The average depth of the flat bogs is 25 feet, although in many places they are from 40 to 50 feet deep, and it is estimated that the quantity of peat amounts to nearly a billion tons.

¹²Irish peat: The Statist. London, Mar. 16, 1918, p. 451.

The British Fuel Research Board has appointed a committee to study the methods of preparing peat in Ireland and to suggest means by which it may be more extensively used in the industries.

England and Scotland.

Prof. W. B. Bottomley, of Kings College, London, has offered to the city of Manchester a free license to manufacture bacterized peat as long as the war lasts. As the municipality owns extensive peat land it is thought that if the offer is accepted the shortage of fertilizer in the agricultural district surrounding Manchester will be materially relieved. It is reported that the demand in England for bacterized peat, or "humogen," as this preparation is sometimes called, exceeds the supply and that it is quoted at \$73 a ton.

The manufacture of surgical dressing from sphagnum is another branch of the British peat industry that has been stimulated by the war. Many tons of sphagnum are gathered from the moors of Scotland and sent to the military hospitals of Edinburgh for use in place of absorbent cotton. Smaller quantities produced in the lake district of England are utilized in the London hospitals.

France.

Peat has been produced by hand and used locally by domestic consumers in France for many years. Stimulated by the high prices of other mineral fuels, the output of peat in 1917 was materially increased and much interest was shown in its potentialities. Peat fuel proved its value even at the battle front, where it was widely used by the French Army in Alsace and in the Vosges for heating and cooking. In Alsatian districts women were engaged in its manufacture and in other sectors it was produced by French soldiers and German prisoners of war.

Switzerland.

The lack of domestic coal fields and the curtailment of imports from Germany have compelled the Swiss people to resort to peat fuel. The quantity of peat available in Switzerland and the proposed method of preparing it for fuel are discussed in substance by the Societe cooperative suisse de la tourbe, of Berne, a semiofficial association created by the Government to stimulate production, as follows:

"It is estimated that 12,355 acres contain peat of good quality and that the total available fuel in this area would amount to about 1,507,990 cubic yards. By using modern machines that homogenize the raw peat and shape it into compact

blocks the imperfections of the hand-cutting process are avoided and large quantities of fuel can be produced in a relatively short time. Cut peat is bulky, easily crushed and quickly re-absorbs moisture, whereas machine peat is compact and resists the absorption of water even when immersed."

The Swiss Government has reserved the right to requisition stocks of prepared peat as well as all the peat deposits and will fix maximum prices when the output reaches proportions that warrant the action.

About 30 years ago an attempt was made in Switzerland to produce peat in large quantities, but on account of the cheapness of German coal the project was abandoned.

Italy.

That the peat industry of Italy prospered in 1917 is indicated in the following excerpt:¹³

"Peat is now produced from numerous bogs in Italy to supplement the coal supply. Attention has also been directed to peat as a source of gas and of byproduct ammonium sulphate. The latest experiments were conducted at Codigoro, where it is alleged a successful process has been discovered. Crushed peat is fed into the furnace of a gas producer in which combustion is regulated by steam and hot air. The peat burns at the bottom of the feed shaft, and, reacting upon the steam, forms water gas and ammonia. These gases are next cleansed of tar by means of a scrubber and are subjected to a fine shower of sulphuric acid, which converts the ammonia into ammonium sulphate and purifies the water gas. After being cooled the water gas may be used under steam boilers, in internal-combustion engines, and for other purposes. It is said that peat containing 2.5 per cent of combined nitrogen, when treated by this process, yields 170 pounds of ammonium sulphate per ton. The first gas producer in which this process was used produced 50 tons of ammonium sulphate from 45,000 cubic feet of peat, as well as a large volume of gas, which was consumed in an 800-horsepower electric plant. Other gas producing plants were erected, and it is reported that the promoters of the process are annually manufacturing more than 3,500 tons of ammonium sulphate from about 17,000 tons of dried peat."

Canada.

Although Canada contains a large number of workable peat deposits little is being done to develop them commercially. According to Director Haanel¹⁴ of the Canadian Commission of

¹³Indian Engineering, vol. 59, p. 201, 1917.

¹⁴Haanel, E., Peat as a source of fuel: Canadian Commission of Conservation Ninth Ann. Rept., p. 4, 1918.

Conservation, the Mines Branch has examined approximately 175,000 acres of peat bog, estimated to contain 115,000,000 tons of peat fuel. Despite these vast peat resources there was no commercial production of peat in Canada in 1917. In 1916 the production of peat fuel amounted to only 300 short tons, valued at \$1,500, compared with 300 tons, valued at \$1,050, in 1915 and 685 tons, valued at \$2,470, in 1914. This condition of inactivity is accounted for by the fact that Canada has thus far been able to supplement her own inadequate output of coal with imports from the United States.

The possibilities of utilizing peat to solve the fuel problem of Canada is well summed up by R. O. Wynne-Roberts¹⁵ in substance as follows:

"It is somewhat remarkable that, while Canada has had much difficulty in obtaining coal from the United States, we have great deposits of peat that could be utilized. This situation is doubtless due to our more intimate acquaintance with coal and to the lack of practical experience in preparing peat. * * * The problem which confronts Canada is not one of conservation, but to determine the best means of making domestic supplies of low-grade fuels available. The great coal measures of Canada are situated in the extreme western and eastern parts of the country, and lying between these points is a vast territory devoid of coal fields, which is now dependent on foreign sources for fuel. In one sense conservation is being practiced to a high degree, because in certain parts of the country practically all the coal required for industrial and domestic use is being imported from the United States, while valuable local fuel deposits are lying undeveloped. However, this kind of conservation never leads to commercial or industrial prosperity, and can not, therefore, be recommended."

New Zealand.

It is reported that a company was organized in New Zealand in 1917 to extract kauri gum oil from the peat deposits in the northern part of the island. Several years ago a company formed for the same purpose abandoned the project after a short time because the methods and machinery were unsuited for the enterprise. It is said that the peat yields from 20 to 25 gallons per ton of light-gravity oil suitable for motor fuel, as well as several varieties of heavy oil, some of which can be used in the manufacture of varnishes. Extensive deposits of peat containing large quantities of kauri gum are located in northern New Zealand.

¹⁵Peat and its utilization: Canadian Min. Eng., vol. 32, pp. 216-218, 1917

China.

A peat deposit in Fuiken Province, about 80 miles from Amoy, China, has recently been examined by chemists. Analysis of a sample of the peat from this bog is as follows:

ANALYSIS OF PEAT FROM FUIKEN PROVINCE, CHINA.

Volatile matter	61.52
Fixed carbon	24.77
Sulphur	1.19
Asn	12.52

FUELS OF MANITOBA, CANADA.

* A. Anrep, mines branch, Department of Mines, Canada, has investigated eighteen bogs in Manitoba. He reports that there are bogs in the Winnipeg River district containing 1,860,000 tons of peat fuel, 25 per cent moisture.

With its enormous coal resources, however, Western Canada will, for many years, depend upon coal and wood for heating and cooking. At the present time, the high labor cost, alone, is sufficient to render peat manufacture an unprofitable enterprise.

In Western Canada, to meet the abnormal conditions created by the war, peat may be prepared and stored on a small scale by farming communities and villages where such are situated near peat bogs. Such fuel supply would not only increase the fuel supply, particularly during the autumn and spring, but would release railway cars that are urgently needed for other purposes.—(Can. Eng. 1918, vol. 35, p. 245.)

TEXTILES FROM PEAT IN DENMARK.

In Sweden and also in Denmark experiments have been carried on for some time in the manufacturing of cloth from peat, and a Danish factory has produced the first pieces of this cloth, which, according to a Danish newspaper, looks well, is of a grayish color, and is not so very different in appearance from woolen cloth. It is made of 75 per cent peat and 25 per cent woolen waste. It is the intention to start several such factories where the raw material is easily obtainable. The patent has been sold recently to several foreign countries, including Norway, where similar factories will probably be started. It is the fibers in the peat that are employed for making cloth. Paddings, upholstery material, etc., may also be made. At an exhibition lately held at Goteborg, Sweden, there were shown knitting machines in use making hosiery from peat yarn.—(Consular Report.)

Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York, City.

Dear Sir:—

I, the undersigned, being interested in the development of our peat resources and in the welfare of the peat Society, beg to make application to membership in your Society for which I enclose \$5.00 as annual dues.

Signed

Address

.....

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RELIABILITY OF PEAT STATISTICS?

The first thing to be done in constructing a statistical table is to form a clear and precise idea of what the table is to show, and to express that idea in accurate language. This matter, unfortunately, is often neglected and it is a source of much waste of time and misapprehension to those who have occasion to study the figures thus presented. No table ought to be considered complete without a heading accurately describing its contents or else the terms used should be properly defined. This, of course, frequently necessitates that the headings should be rather long.

"Figures tell no lies" is a remark often made, but when applied to statistics you can add "provided the figures are not of an ambiguous character."

What does all this refer to? In our last issue we published the Government figures on peat for 1917, and we read there that 97,363 short tons of raw peat were produced, yet 97,363 short tons comprise the quantities of peat fertilizer and peat used in stock food. Raw peat is the term used to designate peat as it is excavated from the deposit and can contain anywhere from 75 to 95 per cent. moisture. This would give approximately about 650,000 short tons of raw peat mined, assuming that all the peat in the finished products contained around 15 per cent. moisture. However, this tonnage was not mined as quite a considerable amount of peat is disposed of in a wet condition, furthermore certain quantities are disposed of with 30 per cent. moisture content. Therefore, the figures given in the U. S. Geological report for 1917 are somewhat misleading.

In giving figures on peat it is generally understood among engineers that the amount of peat be expressed in terms of peat theoretically dried. It is of importance that this standard be adhered to otherwise our statistics and calculations lead to confusion and unreliability.

Just how much of the 92,263 short tons of peat fertilizer was sold wet, and how much with 10 to 15 per cent. moisture is hard for us to determine, but we conjecture that about half of the peat reported was disposed of wet and the other half dried to contain between 10 to 30 per cent. moisture. The 5,100 tons of peat disposed of as stock food was undoubtedly a dried material with about 10 percent. moisture content.

ORGANIC MATTER OF HUMUS.

Any person who has had farm experience knows how necessary organic matter is to the well-being of the soil—how it prevents baking and packing—how it holds water like a sponge—how it actually adds to the “life” of the soil by furnishing food for countless millions of beneficial bacteria. The maintenance of the humus of our cultivated soils is indeed one of the big problems of our agriculture.

In the old days barnyard manure was looked upon as the chief source of organic matter. In fact, even today there are many who believe it to be impossible to farm permanently without the use of animal manure. They admit that plant food can be furnished in fertilizer, but fail to appreciate the fact that fertilizer as used enables the soil to produce its own organic matter.

As a matter of fact, animals produce no organic matter—they destroy it. A crop of clover turned under may add to the soil 3,000 pounds of organic matter. If, however, the same crop be fed to stock and the manure most carefully saved and returned to the soil, the amount of organic matter would be less than half of this quantity. The difference represents humus-making material destroyed—burned to make heat and to furnish muscular energy.

The growing crop is the source of all the organic matter of the soil. Its roots add some organic matter. The stubble adds still more; stem and foliage, fruits and seeds add their quota. Regardless of whether it be a livestock farm, on which manure is produced; or a grain or truck farm where no manure is produced, the principle that large crops increase the organic supply of the soil is of universal application.

In fact, we can go a step farther and present as a general principle the following paraphrase from an experiment station bulletin.

“The easiest way to maintain the organic matter of the soil is to make the soil produce large crops.”

This is eternally true—it is in fact both the easiest way, and practically the only way; and the extent to which fer-

tilizers increase crops is in a way a measure of their effect in bettering the humus conditions of the soil.

Years ago a common theory was "Stuff your land with organic matter—make your soil plant food available so you won't have to buy fertilizer." It is significant that today we hear less of this doctrine, but more of the constructive idea of using fertilizer as humus-making crops. Plant food is necessary for the production of organic matter, and must be supplied before the initial step in the reclamation of the soil can be taken.—The American Fertilizer, 1919, Vol. 50, p. 60.

PEAT AS A MANURE SUBSTITUTE.*

By John S. Burd.

Chemist in Charge of Fertilizer Control, Professor of Agricultural Chemistry, University of California.

The present tendency of soil and fertilizer investigations is to emphasize the importance of materials of organic origin as soil amendments. The virtue of such substances lies partially in the fact that they invariably contain small proportions of necessary chemical elements (so-called "plant foods"), but considerable importance is also attached to certain characteristic properties of the organic (non-mineral) components. Among these may be mentioned their great water-holding power, capacity for serving as nutrient media for certain beneficial organisms (bacteria, molds, etc.), and indirect action on the mineral particles of the soil or the soil solution.

Soils of the humid region normally contain several per cent of organic matter. The amount depends upon many factors, but the finer soils (clays and loams) usually carry more than do the coarse soils (sands). In California and other arid sections the high temperature and low and variable moisture content have the effect both of preventing the accumulation of organic matter and of causing it to disappear rapidly from cultivated soils of all kinds. The average organic matter content of arid soils seems to be less than 1 per cent, i. e., from one-half to one-quarter that of similar soils of the humid region. Additions of even large amounts of decaying organic matter to arid soils will only serve to raise the amount of that material temporarily, because the conditions are unfavorable to its accumulation. Indeed, if organic matter is to be effective the material must decay and thus disappear from the soil.

To maintain the organic matter in arid soils, therefore, requires the constant addition of the manure of domestic animals, green manures or cover crops, or of straw or hay which

*Reprint of Circular 203, Aug., 1918.

has been rendered unfit for animal feed. Any kind of vegetative tissue which is capable of decay in the soil may be used but it is exceedingly doubtful if materials from other sources are worth any more than the cost of application. This means that the farmer should use such waste materials from his own place but that their agricultural value is too problematical to warrant their purchase from others.

Evaluation of Manures.

The well-known deficiencies of arid soils with reference to organic matter have caused our farmers to search everywhere for such material. The value of manure as a soil amendment is unquestioned, but different lots may vary in effectiveness and a determination of their relative values presents an exceedingly complex and technical problem. The whole question of soil fertility is involved and farmers may not hope in the present state of our knowledge to obtain exact statements as to the commercial value of a given lot of manure. The following principles are suggested as the proper basis for purchasing farmyard manure.

1. Whenever possible buy on a basis of the organic content of the material.

2. If several lots of manure are procurable at different prices, the cheapest "buy" may be determined by dividing the price per ton by the percentage of organic matter (i. e., the price per unit of organic matter).

3. The nitrogen content of the manure may be ignored because the nitrogen will vary with the organic within sufficiently narrow limits for this purpose.

4. Ignore the phosphoric acid and potash of the manure because the former is usually insignificant and the latter is relatively unimportant as a fertilizer on California soils.

5. Considerable variation in the amount of added straw in manure is permissible as dry straw contains more organic matter than fresh manure.

6. The amount of water and sand or stones is not material if the manure is purchased on the unit basis for organic matter, except that it increases the transportation charges.

7. A limited amount of sawdust or shavings in manure is to be regarded as legitimate, but manures containing excessive amounts should be rejected.

8. Manures containing sticks or visible woody material other than sawdust or shavings should be rejected even if offered at a lower price.

We are well aware that there are certain very practical obstacles to the purchase of manures on the unit basis of organic matter. A strict regard for the other principles outlined will, however, if combined with a little common sense and

experience enable anyone to buy as effectively as the market conditions permit. Chemical analysis for nitrogen, phosphoric acid and potash are of minor value and constitute an unnecessary expense or actual waste of time on the part of the Experiment Station. Such analyses will ordinarily be refused.

Humus Versus Total Organic Matter.

A great deal of loose talk is heard with reference to humus in the soil. If by humus is meant organic matter of vegetable origin capable of decay under the conditions existing in normal soils, the use of the term is perhaps legitimate. The term humus, however, is ordinarily applied to that portion of any material of organic origin which is soluble in dilute alkalies. The use of the term in this sense was quite common a few years ago. It is, however, now generally recognized that the humus determination in soils and soil amendments is absolutely worthless as an indicator of fertility or fertilizing value. The reason for this is that solubility in alkali affords no guaranty that any portion of the material so dissolved will decay in the soil; furthermore organic matter which is not soluble in alkalies may decay and be a valuable addition to the soil.

The well-known defects of the humus determination and the conviction that it has no meaning in terms of soil fertility lead us to urge the abandonment of the use of this term. Farmers should therefore purchase manures or manure substitutes without regard to humus content, but with strict regard to the probable total of organic matter.

Concentrated Manure, Humus and Peat.

The term manure, as used in this country, is confined to the excrements of domestic animals more or less mixed with bedding material. Concentrated manure should only be used with reference to manure which has been dried. The use of the term manure or concentrated manure when applied to substitutes of other origin is fraudulent. For the reasons indicated heretofore any representation put forth in attempts to sell any substance which includes a statement that the material contains a definite percentage of humus is either fraudulent in its intent or based on ignorance of the present status of the humus determination.

Deposits of partially decayed remains of plants owing their preservation to submergence in water are technically known as peat. It is not legitimate to refer to such substances as humus or concentrated manure, no matter how they have been treated. Their uses and limitations as soil amendments are set forth hereafter.

Peat Soils.

While normal soils contain only a few per cent of organic matter, certain soils contain very large proportions of this

material and the mineral constituents are relatively low. This class comprises muck and peat soils, the latter of which may contain in the dry state 80 per cent or more of organic matter. Peat soils owe their origin to the fact that successive generations of native plants growing in standing water become submerged on completing their growth and the processes of decay characteristic of normal soils do not take place. The excess of water prevents the access of air and acts as a preservative. In this manner successive layers of plant residues are laid down year after year and the deposits may accumulate to a considerable depth. In the peat so derived the structure of the plants to which they owe their origin is still intact and gives testimony as to the incompleteness of their decomposition. Peat soils may occur in any place where native growth is prolific and where such growth becomes submerged. They occur extensively in glaciated regions in the glacial ponds or lakes and also in marshes and low-lying lands elsewhere. In the "delta" region of the San Joaquin and Sacramento rivers in California large areas of peat lands are under cultivation; more limited areas occur in other parts of the state.

As stated above, large areas of peat lands are under cultivation and when properly drained and free from disease may produce excellent crops of barley, potatoes, etc. These soils are usually highly acid, even in the well-drained and aerated surface soil; at the same time they frequently contain considerable quantities of soluble salts. In common parlance such soils would be said to be both acid and "alkaline." There is this difference between the real acidity and the so-called "alkalinity" that the acidity does not seem to be sufficient to prevent the growth of good crops but that the soluble salts tend to increase under cultivation and cause a falling off in yield after several years.

Peat as a Soil Amendment.

Owing to the dearth and high price of farmyard manure it is not surprising that the practically inexhaustible supply of peat with its high organic content has been suggested as a possible substitute for this valuable amendment.

A discussion as to the value of any material used to improve the producing capacity of a soil must be based in part on the amount of the important constituents and in part upon their so-called availability. It is evident that very small percentages of the important constituents in a fertilizer or amendment cannot have any material effect in modifying the composition of a soil, no matter how "available" they may be; on the other hand, large percentages will be equally ineffective if of low availability.

The two constituents which peat might be expected to add to a soil when used as a fertilizer or amendment are organic matter and nitrogen. The total organic matter and total nitrogen of fresh peat approximate more nearly in amount to that of farmyard manure than to any other substance commonly applied to soils. We may, therefore, logically compare peat with manure, a method which has the additional advantage of using as a standard a material of well-known agricultural value.

ANALYSES OF PEAT

(Expressed as percentages of the fresh material)

	Surface 1	Sub- surface (drained) 2	Sub- surface (wet) 3	Sub- surface (wet) 4
Water	66.23	68.93	64.74	78.11
Organic matter	18.74	24.37	22.28	13.84
Mineral matter (ash)....	15.03	6.70	12.98	8.05
Total	100.00	100.00	100.00	100.00

PLANT FOOD CONTENT OF PEAT

(Three different samples)

	Per cent	Per cent	Per cent
Nitrogen	0.61	0.86	0.49
Phosphoric acid	0.16	0.17	0.12
Potash	0.19	0.12	0.06

Farmyard manures are of variable composition, depending on the kind of animal, age, method of feeding, amount of straw, etc. We may take as an average for fresh manure with some straw about 20 per cent of organic matter, 0.50 per cent nitrogen, 0.25 per cent phosphoric acid and 0.60 per cent potash. The peat analyses here given show that this material contains roughly about the same total of organic matter (varying from considerably less to slightly more) than manure; that the nitrogen content of both substances is about the same (many samples of manure contain more nitrogen than many peats); and finally, that the peats all contain much less phosphoric acid and potash than the average sample of manure. It is clear that even if it were true that the organic matter of fresh peat decomposes with the same facility as that of manure and if the availability of the so-called plant foods in peats is equal to that of manure, the peat could not possibly be considered as of equal value to the average fresh manure.

Decomposability of Peat.

A peat soil, even when drained and aerated, or a pile of the same material, will maintain its initial appearance almost indefinitely, in marked contrast to the manure pile, in which fundamental changes may be observed from time to time. No one who has made such observations can fail to be impressed by the difference between the two substances and the obvious inertness of the former. It is evident that such inert material as peat is incapable of the rapid decay usually associated with "available" materials like manure.

Much work has been done by several investigators on the nitrogenous constituents of peat. The general conclusion with reference thereto may be epitomized by the following quotation:¹ "Practically all the nitrogen in the peats is of organic nature. Through weathering the organic nitrogenous bodies present in the brown peat change quite slowly."

We have observed in this laboratory that peat from California sources is similar to that from other sources referred to above in that its nitrogen consists of almost entirely of organic nitrogen and not of the highly available nitrate and ammonia salts. The Citrus Experiment Station at Riverside has made similar observations and, in addition, nitrification studies which unquestionably demonstrate the low availability of peat nitrogen. The conclusions reached in these experiments are indicated from the following excerpt from a report of Dr. W. P. Kelley, Professor of Agricultural Chemistry, Citrus Experiment Station, Riverside, California:

"* * * After the above experiments has stood for a year a study was also made of the effects that had been produced on the solubility of the various plant foods present. The results showed that in neither case had any appreciable effect been produced by the peat. The manure and alfalfa hay, on the other hand, had notably increased the solubility of the various plant food elements present.

"From the preceding results, it is evident that the peat used in these experiments is an extremely inert substance, and that it is of such nature as to be practically unaffected by the action of soil bacteria. The fact that the peat produced no effect either on nitrification or denitrification, on the one hand, or on the solubility of the plant food constituents contained in the soil, on the other, is especially strong evidence in support of this view. It would appear reasonable to conclude, therefore, that the chemical and biological effects produced by this material, at least for the first year after it has been applied,

¹Tech. Bull. No. 4, Michigan Agr. College, Nov., 1909, p. 28, Organic Nitrogenous Compounds in Peat Soils.

will be negligible, and since the plant foods contained in the peat itself are largely unavailable, the effects that will be produced on crops under field conditions, will probably not be great.

"In addition to the above experiments, I have frequently observed the conditions in certain citrus groves near Riverside where peat has been in use for some time, but as yet no apparent effects have been produced on the growth or well-being of the trees. The lumps of peat can still be seen in the soil, and careful examination shows that it has not undergone any apparent change. Ordinarily, stable manure when applied in this section becomes completely decomposed in much less time than has elapsed since the application of peat in the groves referred to.

"In view of the well-known experiences of peat in the groves in other parts of the world, and the information derived from the above studies on this material, it seems safe to conclude that the farmer in California is not justified in placing more than a nominal fertilizing value on this material.

(Signed) W. P. KELLEY."

In the laboratory of Agricultural Chemistry at Berkeley we have demonstrated that virgin peat soils gave a three-fold crop when fertilized with phosphate fertilizers, indicating very clearly that the phosphate in fresh peat is likely to be highly unavailable. We have made no studies as to the availability of potash in peat, but as stated above, the total potash is so small as to be negligible. Peat contains from a third to a tenth or less potash than the normal California soil so that its addition would actually decrease the percentage of total potash in soils on which it is used.

Concentrated Peat.

Peat, like any other watery material, can be concentrated by the simple process of evaporating the water. The effect of this is to increase the amount of each non-volatile constituent in proportion to the loss of water. The advantage to be derived from this practice is that the resulting material weighs only about a third as much as the original peat and contains about three times as much of each constituent (other than water) in a ton of dried material.

If peat has any fertilizing value the drying is justifiable in that it saves about two-thirds of the transportation charges if the drying is thorough. Such substances tend to absorb considerable quantities of moisture from the air, however, so that the proportionate increased concentration estimated above represents a maximum figure for peat of average composition.

III Effects of Drying.

Drying or desiccation of vegetable material has been observed to decrease its capacity for rapid nitrification, even when subsequently moistened and added to soils.² A portion at least of the benefit of drying peat may be lost by a lowering of the nitrifiability of the material.

Dried Peat Versus Farmyard Manure.

The statement is frequently made that dried peat is more concentrated than fresh farmyard manure. This is true but it is quite possible to dry farmyard manure and thus obtain a much more concentrated product than dried peat. The reason for this is that while fresh peat and fresh farmyard manure contain about the same percentages of organic matter, the remaining material in manure is largely water, while peat normally contains much more of valueless ash or mineral ingredients which reduce the percentage of organic matter in the dried product.

Inoculated Peat.

The claim is frequently made that peat may be advantageously inoculated with various organisms, thereby increasing the availability of its nitrogen content or enhancing the nitrogen-fixing power of soils to which it is applied. A very clear exposition of the prevailing opinion of scientific men with reference to the possibilities of inoculating peat may be obtained from the following letter from Dr. Chas. B. Lipman, Professor of Soil Chemistry and Bacteriology, University of California:

"* * * The only extensive studies which have been made on the inoculation of peat are those which were carried out in England by Bottomley and his associates at the University of London, and those carried out by Voelcker at the Woburn Experiment Station by Russell and his associates, at the Rothamsted Experiment Station, and by Chittenden, both of which latter were intended to check the claims of Bottomley. Mr. Bottomley's claims were that peat is very much improved for purposes of soil amendment by its inoculation with bacteria closely similar to many of the so-called ammonifying or ammonia-producing bacteria in the soil. The idea involved is that the very inert organic nitrogenous compounds contained in the peat are rendered soluble and easily hydrolizable through the action of the micro-organisms. It has been further claimed by Bottomley that some of the dissolved organic compounds thus produced may serve after the sterilization of the peat as markedly efficient sources of energy for micro-organisms which have the power of fixing nitrogen

²Stewart, G. R., Availability of the Nitrogen in Pacific Coast Kelps, Journal of Agricultural Research, Vol. IV, No. 1, April, 1915.

from the air, and which have been introduced into such sterilized peat. The material thus prepared is commercially known as 'Humogen' or bacterized peat. Bottomley and some of his commercial supporters have carried out experiments and shown photographs of the plants involved, which are calculated to substantiate their extravagant claims for the improvement of the peat through inoculation.

"The other English experiments which are referred to above, however, have given little or no support to the claims made by Bottomley. Chittenden and Russell, in particular, have gone on record as saying that, in their experiments, the plants grown on soils treated with the bacterized peat do not seem to have been affected beneficially any more than plants grown on similar soils not treated with that substance. In view of the fact that such careful experiments, probably among the most conservative in the field of agricultural science, have made these statements renders it necessary for any one commenting on the subject in question to decide that the public will be unjustly and unscientifically advised if it is not warned that many more experiments by careful students of the subject are necessary before the exact facts in the case can be ascertained. In view, therefore, of this situation, coupled with the traditional information which we have always had relative to the inert nature of peat and its ineffectiveness when applied to soils, make it necessary for me to advise against the acceptance by the public of any statements made on the superior nature of inoculated as against uninoculated peat, as well as on its value as a source of nitrogen and even of organic matter to soils.

(Signed) CHAS. B. LIPMAN."

Sand or Silt in Peat.

When peat beds are subjected to the influence of rising or falling water they are always more or less contaminated with mineral particles of sand, silt, or clay. The effect of this is to render the resulting material still less valuable as a soil amendment, the mineral particles constituting a worthless filler.

Summary.

1. The substances commonly included in the term organic matter and derived from plant or vegetable tissues have a recognized value as soil amendments apart from their plant food contents.

2. Organic matter is contained in manures of all kinds, in straw, hay, etc., and in peat.

3. The commercial value of substances of the same kind, such as manures, should be based upon their percentages of organic matter.

4. Fresh peat contains about the same amount of organic matter as the average fresh manure.

5. Dried peat will normally contain less organic matter than manure of the same degree of dryness.

6. Peat, unlike farmyard manure, does not decay rapidly in the soil, nor is it readily nitrified; it cannot, therefore, be regarded as an "available" material.

7. We regard the inoculation of peat as a useless procedure and an unnecessary expense to the farmer.

8. Peat frequently contains considerable sand or silt, making it still less valuable agriculturally.

9. Any plant substance which has undergone partial decay in water is to be regarded as peat.

10. In the absence of more favorable results than those heretofore obtained in experiments with peat, the use of this material is not advised.

11. Farmers are expressly advised that the plant food constituents of peat are not to be regarded as having the same commercial value as those of high-grade fertilizers nor is peat commercially or agriculturally as valuable as farmyard manure.

SOIL ACIDITY AS AFFECTED BY MOISTURE CONDITIONS OF THE SOIL.*

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Introduction.

In an investigation of soils from tiled and untilled land it has been found that the drained was not as acid as the undrained soil (ϱ).¹ To throw more light on the effect of moisture on soil acidity, five typical acid Indiana soils were selected for investigation under controlled moisture conditions: Soil A, a yellow silty clay from Jennings County; soil B, a whitish silt loam from Jennings County; soil C, a brown silt loam from Tippecanoe County; soil D, a black peaty sand from La Porte County; and soil E, a dark-brown peat from De Kalb County.

Equal quantities of each of these soils, the analyses of which are given in Table I, were kept in pots in the greenhouses at full water-holding capacity, at one-half water-holding capacity, and at one-fourth water-holding capacity. Other portions of each soil were taken when pots were filled and kept in an air-dry condition in the laboratory. The pots were of galvanized iron of 770 cubic inches capacity, heavily coated

*Reprint from Jour. Agri. Res. Vol. XV, 1918, p. 321.

on the inside with paraffin. The soil in each pot was kept under the desired moisture conditions by weighing them two or three times each week and replenishing the evaporated moisture with pure distilled water. The water-holding capacity of each soil was determined by placing a perforated bottom cylinder containing about 100 gms. of loose dry soil in a vessel of water and allowing the sample to become thoroughly saturated, then weighing. The soils fully saturated with water soon became more or less puddled, and the moisture determinations of these samples taken at the end of the test showed less than the calculated percentage of water. The moisture determinations of the samples with one-fourth and one-half water-holding capacity were approximately the same as the calculated percentages. The soils were placed in the pots February 27, 1917, and the experiment was continued for one year, after which they were sampled by means of a soil tube, taking a vertical core of soil to the full depth of the pot. Each sample was thoroughly mixed and divided into two portions, one of which was sealed in an air-tight jar. The other was spread out and air-dried in the laboratory. Moisture was determined in both the moist and the air-dry samples. Acidity was determined by the Hopkins potassium-nitrate method,¹ by the C. H. Jones calcium-acetate method (4), and by the ethyl-actate method (1). The results of these determinations are given in Table II. In making the acidity determinations, the moisture contents of the soils were taken into consideration so that the proportions of dry soil to water and reagent used in making the tests were the same for all samples of both wet and air-dry soils.

TABLE I.—Analyses of soils used.

TABLE I.—Analysis of Soils Used.

Determined.*	A. Per cent.	B. Per cent.	C. Per cent.	D. Per cent.	E. Per cent.
Volatile matter	3.57	3.92	7.45	10.13	85.20
Potassium oxid (K_2O) .....	.27	.25	.40	.21	.17
Calcium oxid (CaO) .....	.18	.17	.37	.10	.46
Magnesium oxid (MgO) .....	.40	.24	.61	.23	.20
Manganese oxid (Mn_2O_4) .....	.08	.04	.17	.04	.02
Ferric oxid (Fe_2O_3)	3.68	1.28	3.04	1.04	.48
Aluminium oxid (Al_2O_3)	4.68	2.80	4.57	3.09	.85
Phosphorus oxid (P_2O_5) .....	.05	.06	.15	.10	.13
Sulphate (SO_3) .....	.12	.10	.16	.11	.31
Residue	87.76	92.57	83.42	85.50	12.31
Nitrogen .....	.07	.12	.22	.40	2.04
Humus (acid)† .....	.73	1.31	2.25	5.72	50.19
Humus‡ .....	.70	1.17	3.13	4.96	52.00
Hygroscopic moisture	1.50	1.30	1.84	1.90	8.38
Acidity:					
Potassium-nitrate method§ ...lb.	5.460	2.220	460	2,520	5,080
Calcium-acetate method§ ...lb.	5.875	4.875	8.125	10,625	69,750
Water-holding capacity¶	48.6	48.7	55.1	67.1	200.0

*Wiley, H. W., ed. Official and Provisional Methods of Analysis, Association of Official Agricultural Chemists as compiled by the Committee on

¹Wiley, H. W., ed. Op. Cit.

Revision of Methods. U. S. Dept. Agr. Bur. Chem. Bul. 107 (rev.), 272 p., 13 fig. 1908. Reprinted, 1912.

†Ammonia soluble without previous washing with dilute hydrochloric acid.

‡Washed with hydrochloric acid, digested with ammonia, filtered, and refiltered till clear.

§Pounds of calcium carbonate required to neutralize 2,000,000 pounds of soil.

¶Water-holding capacity in grams of water per 100 gm. of dry soil.

In studying the results given in Table II, the following rather striking points are noted:

In each soil the degree of acidity, as indicated by all the methods used, was greater when the soil was held at one-half water-holding capacity than when it was held at one-fourth water-holding capacity.

All the soils which had been carried at one-half water-holding capacity were more acid than they were at the beginning of the experiment. This is in accord with the results obtained by Noyes and Yoder (5).

The soils high in organic matter gave greater acidity when held at full water capacity than when kept one-half saturated with water. The soils low in organic matter gave a lower degree of acidity when kept at full water than when kept at one-half water-holding capacity.

TABLE II.—Relative Acidities of Soils with Different Moisture Conditions, and Changes Due to Drying.

Soil	Moisture treatment.	Potassium-nitrate method.*		Calcium-acetate method.*		Ethyl-acetate method.†	
		Moist.	Dried, Change.	Moist.	Dried, Change.	Moist.	Dried, Change.
A.....	{ Start .....	.....	.....	.....	.....	.....	.....
	{ End .....	.....	.....	.....	.....	.....	.....
	{ 1/2 water .....	.....	.....	.....	.....	.....	.....
B.....	{ Start .....	.....	.....	.....	.....	.....	.....
	{ End .....	.....	.....	.....	.....	.....	.....
	{ 1/4 water .....	.....	.....	.....	.....	.....	.....
C.....	{ Start .....	.....	.....	.....	.....	.....	.....
	{ End .....	.....	.....	.....	.....	.....	.....
	{ 1/2 water .....	.....	.....	.....	.....	.....	.....
D.....	{ Start .....	.....	.....	.....	.....	.....	.....
	{ End .....	.....	.....	.....	.....	.....	.....
	{ 1/4 water .....	.....	.....	.....	.....	.....	.....
E.....	{ Start .....	.....	.....	.....	.....	.....	.....
	{ End .....	.....	.....	.....	.....	.....	.....
	{ 1/2 water .....	.....	.....	.....	.....	.....	.....

* Results expressed in pounds of calcium carbonate required for 2,000,000 pounds soil.
 † Ten gm. of soil were placed in 100 cc. of pure 5 per cent ethyl-acetate solution and shaken at frequent intervals. The solutions were kept in a thermostat at 27° C. for 24 hours. Then 10 cc. of the supernatant liquid was removed and titrated with N/20 sodium hydroxide, phenolphthalein being used as the indicator. The figures reported are the constants calculated from the formula $K=1/t$ (log a/a-x), where a equals grams of ethyl acetate at start and a-x equals grams of ethyl acetate left at t (one day). The constant for N/1,000 acetic acid carried under like conditions was 0.0004 and for N/1,000 nitric acid it was 0.0039. These constants are relative only. Autocatalysis was noted in longer time reactions, but this factor has been ignored in the calculations reported.
 ‡ There was not enough of soil A, and the one-fourth water-holding capacity pot was omitted.

TABLE III.—Soluble Oxids in Normal Potassium-Nitrate Extract of Soils with Changes Due to Drying.
(Results expressed as grams of oxids per 100 cc. of extract from acidity determinations)

Soil	Moisture treatment.	Silicic acid.			Aluminium oxid.			Ferric oxid.		
		Wet.	Dry.	Change.	Wet.	Dry.	Change.	Wet.	Dry.	Change.
A....	{ ½ water	0.0062	0.0065	+0.0003	0.0421	0.0382	-0.0039	0.0020	0.0010	-0.0010
	{ Full water	0.045	0.048	+0.003	0.0179	0.0180	+0.0001	0.0040	0.0020	-0.0020
	{ ¼ water	0.049	0.039	-0.010	0.0207	0.0250	+0.0043	0.0020	0.0020	0.0000
B....	{ ½ water	0.045	0.057	+0.012	0.0210	0.0236	+0.0026	0.0020	0.0010	-0.0010
	{ Full water	0.046	0.024	-0.022	0.0079	0.0078	-0.0001	0.0140	0.0030	-0.0110
	{ ¼ water	0.032	0.036	+0.004	0.0075	0.0070	-0.0005	0.0020	0.0010	-0.0010
C....	{ ½ water	0.037	0.066	+0.029	0.0084	0.056	+0.0028	0.0020	0.0010	-0.0010
	{ Full water	0.034	0.032	-0.002	0.0072	0.054	+0.0018	0.0240	0.0010	-0.0230
	{ ¼ water	0.050	0.054	+0.004	0.0193	0.0258	+0.0065	0.0020	0.0010	-0.0010
D....	{ ½ water	0.056	0.041	-0.015	0.0234	0.0304	+0.0070	0.0020	0.0010	-0.0010
	{ Full water	0.049	0.030	-0.019	0.0225	0.0068	-0.0157	0.0180	0.0040	-0.0140
	{ ¼ water	0.053	0.021	-0.032	0.010	0.0136	+0.0074	0.0020	0.0020	0.0000
	{ ½ water	0.058	0.030	-0.028	0.0199	0.0166	-0.0033	0.0020	0.0020	0.0000
	{ Full water	0.090	0.040	-0.050	0.207	0.138	-0.069	0.380	0.040	-0.340
Soil	Moisture treatment.	Manganese oxid.			Calcium oxid.			Magnesium oxid.		
		Wet.	Dry.	Change.	Wet.	Dry.	Change.	Wet.	Dry.	Change.
A....	{ ½ water	0.0086	0.0064	-0.0022	0.0370	0.0408	+0.0038	0.0116	0.0124	+0.0008
	{ Full water	0.020	0.020	0.000	0.288	0.488	+0.200	0.141	0.135	-0.006
	{ ¼ water	0.035	0.035	0.000	0.350	0.380	+0.030	0.070	0.069	-0.001
B....	{ ½ water	0.034	0.030	-0.004	0.216	0.336	+0.020	0.065	0.056	-0.009
	{ Full water	0.069	0.078	+0.009	0.387	0.448	+0.061	0.087	0.066	-0.021
	{ ¼ water	0.080	0.080	0.000	0.123	0.298	+0.175	0.105	0.028	-0.077
C....	{ ½ water	0.040	0.060	+0.020	0.251	0.302	+0.051	0.130	0.136	+0.006
	{ Full water	0.034	0.036	+0.002	0.814	0.1264	+0.450	0.134	0.132	+0.002
	{ ¼ water	0.040	0.040	0.000	0.122	0.128	+0.006	0.042	0.041	-0.001
D....	{ ½ Water	0.020	0.020	0.000	0.066	0.094	+0.028	0.021	0.028	+0.007
	{ Full water	0.040	0.040	0.000	0.143	0.212	+0.069	0.051	0.041	-0.010
	{ ¼ water	0.052	0.034	-0.018	0.626	0.612	-0.014	0.086	0.054	-0.032
	{ ½ water	0.056	0.034	-0.022	0.541	0.376	-0.165	0.072	0.046	-0.026
	{ Full water	0.034	0.036	+0.002	0.504	0.464	-0.040	0.086	0.055	-0.031

When the samples of moist soil taken at the close of the experiment were air-dried, those samples that had been kept saturated decreased markedly in acidity according to all methods used. When the samples kept at one-fourth and one-half water capacities were air-dried, all decreased in acidity according to the ethyl-acetate method, but the Hopkins and Jones methods gave both increases and decreases in acidity. While the acidity was generally decreased when the soils were air-dried, the degree of acidity equilibrium reached varied to a large extent, owing to the condition of equilibrium caused by the variation in moisture content at which the soil had been held. For instance, while undried soils containing much organic matter gave a higher acidity at full water than at half water capacity, these same soils when air-dried gave a much lower acidity after being held at full water than when held at one-half water-holding capacities. This reversal in order of acidity is not so apparent with soils low in organic matter.

Preliminary tests were made on the soils from samples taken nine months from the beginning. The results obtained with the samples from the pots of fully saturated soil show the extreme sensitiveness of soils to slight variations in moisture. The sample of fully saturated Soil C, taken at nine months, lost some moisture before it was determined, in which condition it had 27.2 per cent of water and 400 pounds' acidity by the potassium-nitrate method. Three months later a sample of soil from the same pot had an acidity by the same method of 2,150 pounds with 30.6 per cent of water. The soil from this pot showed but a slight trace of iron in the potassium-nitrate extract with 27.2 per cent of water and a very large amount with 30.6 per cent of water. This increase in acidity and of soluble iron appears to be due to the fully saturated condition rather than the longer time elapsed.

The relative acidities of the various soils, high or low in organic matter, gave quite wide variations with the different methods. In general, the potassium-nitrate method measures mineral acidity, owing to acid-reacting silicates, and to a less degree it measures acid organic matter in the soil. The calcium-acetate method, on the other hand, measures acidity due to acid-reacting silicates, and in addition it responds readily to acid organic matter. With soils high in organic matter the results due to this method are influenced by organic matter more than by acid silicates. Water-soluble acidity only slightly affects the results shown by either the potassium-nitrate or the calcium-acetate methods. The results shown by the ethyl-acetate test are very largely in proportion to the strength of the water-soluble acidity of the soil. These results would be

affected by nitrates, sulphates, or chlorids of aluminium, iron, and to a slight degree by manganese salts; also by any soluble acid reacting organic matter. Pure silicates which show a very high acidity by other methods and which are not soluble in water do not affect ethyl at all (1).

In titrating the potassium-nitrate acidity determinations, quite distinct differences were noted in the character of the precipitates formed. In order to study this point, determinations were made of the metals which had been dissolved in the reactions between the normal potassium-nitrate solution and the soil. Table III gives the bases and soluble silica found in 100 cc. of potassium-nitrate extract from both the wet and the air-dried soils; also the increases or decreases of soluble matter found on air drying the soil samples. These results show that considerable iron was made soluble when the soil was kept fully saturated. This soluble iron was apparently all in the ferrous state. After the soils were air-dry, the iron was very quickly and almost completely oxidized, as the air-dry soil showed but little soluble iron. This chemical change in the condition of the iron undoubtedly accounts for a large part of the decrease in acidity caused by drying the fully saturated samples. Soluble iron is seldom found in soil solutions in very large amounts, which is undoubtedly due to the fact that the usual procedure in preparing soil samples for analysis is first to air-dry them, allowing ample opportunity for the oxidation of the iron.

There was a great difference in the amounts of manganese found in some of the soils. The manganese, like the iron, appears to have been very largely reduced and made soluble by saturating the soil with water and excluding the air. In soils A and C over one-half the total soil manganese was dissolved by the potassium-nitrate solution. Unlike iron, the manganese did not rapidly oxidize upon air-drying the soil. Undoubtedly, under proper conditions, oxidation of manganese takes place, although much less rapidly than that of iron. In view of the wide variations between the manganese results, new solutions were prepared, and the gravimetric determinations were checked and confirmed by means of the Volhard volumetric and the lead-peroxid colorimetric methods.

The soluble aluminium decreased when the fully saturated soils containing much organic matter were dried. With soils B and D, one-fourth and one-half saturated with water, the soluble aluminium increased on air-drying. This is in accord with the acidity, which likewise increased when these soils were dried. Different investigators have endeavored to correlate the amounts of soluble aluminium and iron with the degree of acidity as obtained with the potassium-nitrate

method. The results given in Tables II and III show a certain correlation along this line, but it is very apparent that the titrated acidity cannot be entirely explained on the basis of the amount of potassium-nitrate soluble aluminium and iron. This acidity is apparently partly due to soluble acid organic compounds in addition to the iron and aluminium compounds.

The amount of calcium in solution varied to a large degree in inverse relation to the aluminium and iron. In all the soils, except the peat (E), the solutions from the air-dried soils contained more calcium than did those from the undried soils. Magnesium and soluble silica showed no striking variations due to the varied moisture conditions.

The changes shown in the degrees of acidity and also the differences in the amounts of soluble bases occurring when the soil samples are air-dried indicate the importance of further study of soils and soil reactions on samples which are kept under field moisture conditions. Some of the reactions which occur when soils are dried are apparently very rapid and so slowly reversible that the composition of dried soils may be quite different from that of field soils.

Moisture Reactions of Acid Soils.

It has been noted by different investigators that carbonated water will extract from a mineral soil a solution that on boiling to drive off the carbon dioxide will be alkaline to phenolphthalein. This fact can hardly be taken as proof that the soil moisture is not acid or that the soil acidity has been regulated by the formation of carbonates. Such an extraction of bases by an acid is, of course, to be expected from the laws of chemistry, but it does not tell in what state of equilibrium the soil bases may have been before they were extracted. Recent researches would indicate that the soil moisture of acid soil is distinctly acid and not basic in reaction. Gillespie (3) working with the hydrogen electrode, has found that solutions of acid soils are distinctly acid in reaction. Sharp and Hoagland (6) likewise found that there is an excess of hydrogenous in solutions of acid soils. In addition they say: Soils containing calcium in equilibrium with HCO_3 and CO_2 have a very slightly alkaline reaction, and the figure for $\text{Ca}(\text{HCO}_3)_2$ is almost identical with those obtained for the alkaline soils.

Truog (7) and Meacham found that the reaction of the plant sap of a number of agricultural plants was always acid. As most plants will grow in slightly acid soils and in slightly acid water cultures, it does not seem necessary nor even possible that in such cases calcium is first transformed into bicarbonate before it is assimilated. As a result of varying the moisture conditions of acid soils it is very evident from the

results given in Tables II and III that chemical reactions take place as different conditions of equilibrium due to moisture and aeration are established. These reactions are in the nature of reduction, oxidation, and hydrolysis as well as interactions following the law of mass action between compounds which may be made chemically active. All of these chemical changes in the soil cause variations in the degree of water-soluble acidity, as shown by the ethyl-acetate reaction as well as of the less-soluble acidity which is shown by the soluble-salt methods. These changes would no doubt also affect the toxicity of acids and other compounds in the soil. For instance, it may be readily seen that the oxidation of iron in the soil from the ferrous to the ferric condition would reduce toxicity as well as acidity. Acid marsh soils containing much iron are unproductive until some time after they have been drained. These soils when properly drained become quite red from oxidized iron, in which condition they are much more productive. This fact is a matter of common knowledge among observant farmers in such regions. It is undoubtedly true that soil processes in which carbon dioxid is evolved also produce material changes in soil acidity (5). Nitrification also increases water-solubility acidity. These biological reactions, of course, depend materially upon soil-moisture conditions.

Factors Affecting Soil Acidity.

Primarily soil acidity is due to an excess of acid-reacting compounds, or, in other words, to a deficiency of bases. The deficiency of bases is caused to a large extent by the leaching of the calcium and magnesium in the drainage waters. A lesser factor is the removal of mineral bases by crops. Under ordinary conditions of decay the carbonaceous and nitrogenous matter of plants takes on an acid character, tending to neutralize bases in the soil. The acidity of peat soils is very largely organic, as shown by the fact that the ash of the most acid peat is basic in reaction. In mineral soils there is an enormous excess of silicic oxid. This silicic oxid when free is insoluble and inactive as an acid; but it is potentially acid, and under humid conditions tends to form chemically-active acid-reacting silicates of iron, aluminium, and manganese. The degree of acidity of aluminium silicate is in proportion to the ratio of silicic oxid and aluminium oxid and also to the amount of combined water the silicate contains (1). Everything else being equal, the more water there is in the silicate, the more active it is chemically and the more acid it is in reaction. The measurable acidity of the organic matter of the soils is also increased in the presence of an excess of water, as indicated from the results obtained with soil E. Drainage conditions

will modify the acidity of either an organic or inorganic soil, and this will have an effect on soil fertility. Of course with soils well supplied with calcium and magnesium, poorly-drained soils would not become acid until a part of the bases were dissolved and washed away.

Summary.

(1) Five different types of acid soils were kept under different moisture conditions in pots in the greenhouse for one year. Portions of soil were kept one-fourth saturated, one-half saturated, and fully saturated; also in an air-dry condition.

(2) Acidity determinations were made by the Hopkins potassium-nitrate method, the C. H. Jones calcium-acetate method, and the ethyl-acetate method. Samples of soil from each pot were tested for acidity both in the moist and in the air-dried condition. The potassium-nitrate extracts were analyzed.

(3) The degree of soil acidity measured by the different methods varied with different moisture conditions.

(4) With each soil and each method used the samples which had been kept half-saturated were higher in acidity than they were at the start of the experiment. The acidity of the half-saturated soils was greater than the acidity of the fourth-saturated soils.

(5) The soils high in organic matter showed the greater acidity when kept fully saturated. The soils low in organic matter showed the greatest acidity when kept half-saturated.

(6) When the moist samples of soil taken at the close of the experiment were air-dried, the fully-saturated samples showed loss of acidity. The half-and fourth-saturated samples showed both gains and losses in acidity when air-dried.

(7) The potassium-nitrate extracts of the fully-saturated soils contained much larger amounts of iron than extracts of other samples. This soluble iron was in the ferrous form and was oxidized and made insoluble when the soils were dried.

(8) With the mineral soils the fully saturated soils had much greater amounts of soluble manganese than the other samples. Drying the soils did not render the manganese insoluble as it did the iron.

(9) There was less aluminium in the fully saturated mineral soils, but with the soils high in organic matter this was not true. There was both increase and decrease of soluble aluminium on drying the soils.

(10) Calcium, magnesium, and silica showed variations in solubility owing to different moisture conditions, but the variations were not as striking as those of iron, manganese, and aluminium.

(11) In correlating the soluble iron and aluminium with the acidity obtained from the potassium-nitrate extracts, it was apparent that the titrated acidity could not be entirely explained on this basis. Doubtless this acidity is partly due to soluble acid organic compounds.

(12) The measurable acidity of acid soils varies to a large degree under different conditions of moisture and aeration. These variations are due to chemical rather than physical changes in the soils.

(13) The extreme sensitiveness of the chemical compounds of soils and the wide variations caused by changing moisture conditions leads to the conclusion that some soil investigations should be conducted with undried samples.

(14) The soil moisture of acid soils is acid in reaction as shown by hydrogen-ion determinations. As the cell sap is also acid it is not necessary to consider that calcium is first changed into the form of bicarbonate before it can aid in nitrification or be assimilated by plants.

(15) A condition of acidity is produced in humid soils due to the leaching of the strong basic elements in the drainage water, by the removal of bases in crops, by the decay of carbonaceous and nitrogenous substances, and by the hydrolysis of mineral compounds and organic matter.

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CONGRESSIONAL APPROPRIATION FOR PEAT.

Since our last issue considerable excitement has prevailed among peaters regarding a certain amount of money appropriated by Congress at Washington for investigations of peat and lignite.

A little history of the Bill will be of interest. In May, 1918, Senator A. J. Gronna introduced a Bill for the appropriation of \$100,000 for the investigation of lignite deposits. Senator Fletcher of Florida, took the matter up with our fellow member and friend Robert Ranson of St. Augustine, Florida, and enquired what he would suggest as an amendment to this Bill to include Peat. Robert Ranson suggested that the words "and Peat" be placed after Lignite, and also that the appropriation be raised from \$100,000 to \$200,000.

The Bill was eventually passed by Congress towards the end of January, 1919, but the final appropriation of \$200,000 had been reduced to \$100,000, which was originally suggested for investigation of Lignite deposits, however, the words "and Peat" placed after Lignite remained.

The Gronna Bill was approved by President Wilson early in February, and authorizes the Secretary of the Interior to investigate domestic deposits of lignite and peat in an effort to develop commercial uses for them. The Bureau of Mines is already preparing to install an experiment plant for lignite, either in the Southern field in Texas or the Northern field in Montana and the Dakotas.

O. P. Hood is the scientist in charge of the preliminary work of the investigation, and it is reported that he will locate the experimental plant near a community, where the by-product gas may be sold, where a market for the fuel is accessible and a good supply of lignite is assured.

It is expected that a carbonizing process will be developed, so that a good quality of commercial gas is obtained, and coke produced which can be burned in ordinary grates in factories, or briquets will be made from same to approximate an anthracite fuel.

The Executive Committee of the American Peat Society became active in this direction, as the Society wishes to be of as great a benefit as possible to the Government and country.

The resolutions and correspondence ensuing from these meetings is published herewith:

Copy of Preamble and Resolutions passed by Executive Committee of American Peat Society at a Special Meeting held at the office of the Society in the City of New York, on March 11th, 1919.

WHEREAS: Congress has appropriated a certain amount of money to be expended on peat investigations, and

WHEREAS, Previous investigations, except along agricultural lines, did not obtain practical results, and

WHEREAS, Investigations of the U. S. Dept. of Agriculture made in co-operation with the American Peat Society have obtained practical and beneficial results, and

WHEREAS, It is the object of the American Peat Society to obtain beneficial and practical results, therefore, be it

RESOLVED: That the American Peat Society be prepared to co-operate with the Director of the U. S. Bureau of Mines in the proposed investigation, and be it further

RESOLVED: That the President of the Society be authorized to appoint the Chairman of the Executive Committee to represent the Society in conference with the U. S. Bureau of Mines and to arrange for a meeting with Mr. Van H. Manning, the Director, at such time and place as the Director may indicate, and be it further

RESOLVED: That, if the Director of the U. S. Bureau of Mines so requests, the President of the American Peat Society will appoint a special committee of members, of which he shall be Chairman, to act in co-operation, or in an advisory capacity, to the U. S. Bureau of Mines, and further be it

RESOLVED: That a copy of Memorandum of Understanding between the American Peat Society and the Bureau of Plant Industry, U. S. Department of Agriculture, in effect June 16th, 1913, together with a copy of these resolutions be sent to Director Van H. Manning, U. S. Bureau of Mines, Washington, D. C., that a copy of these resolutions be spread upon the minutes of the Society and published in the Journal of American Peat Society.

EXECUTIVE COMMITTEE.

(Signed) J. N. Hoff, Chairman,
G. Herbert Conduct,
Herbert Philipp.

A true Copy:

Attest:

Chas. Knap, Sec'y American Peat Society.

Department of the Interior, Bureau of Mines,
Washington, March 12, 1919.

American Peat Society,
No. 17 Battery Place,
New York, New York.

(Attention: Mr. Chas. Knap, Sec'y-Treasurer.)

My dear Sir:—

Please convey to the American Peat Society my appreciation of their offer of co-operation in any investigation which the Bureau will undertake on the subject of Peat.

The recent bill authorizing an investigation of lignite and peat originated as a lignite bill. About the same time a second bill before Congress was introduced authorizing a similar investigation of peat and carried a separate appropriation. The people interested in lignite were very active and succeeded in getting favorable consideration of the bill. The peat bill died. The lignite bill in the Senate was amended by adding the subject of peat and adding \$50,000 to the appropriation. As finally passed, the \$50,000 was stricken from the bill, but the word "peat" remained.

It is quite evident from this situation that in order to keep faith with those interested in lignite, that problem must be first considered and its successful prosecution assured before dividing our funds between the two subjects. The engineers of the Bureau are concentrating on the lignite problem at the present time. When the matter of peat is to be taken up the Bureau will be very glad to avail itself of the help which your Society can give, and I shall request the Bureau's engineers to confer with your committee.

Very truly yours,
Van H. Manning, Director.

GEORGIA'S STATE CHEMIST'S REPORT ON PHOS-PHO-GERM & EARP-THOMAS' REPLY.

Below we reprint the "Report of the State Chemist of Georgia in the Examination of Phos-pho-Germ" and a reply to the same by Mr. G. H. Earp-Thomas, the inventor of the same: Hon. J. J. Brown, Commissioner of Agriculture, Atlanta, Ga.
Dear Sir:

During December, you directed your laboratory to analyze samples of "Phos-pho-Germ," a so-called soil vitalizer, and to investigate the truth of the extravagant claims made for this material. I have had thorough chemical and bacteriological examinations made of Phos-pho-Germ and this report is given for your information and for the information of the farmers of Georgia.

I do not believe that Phos-pho-Germ has the agricultural value claimed for it; I do not believe that it is adapted for general or wide-spread use on our types of soil; and I do not believe that the price charged for it is anywhere in the bounds of reason. I have arrived at these conclusions from a consideration of the data given in detail below.

I strongly recommend that this information be given to the farmers to warn them against buying such a material as this, especially as it is being passed off for a superior product and exaggerated claims are being made for it which I do not believe can be substantiated in reference to our soils. Phos-pho-Germ is a product made by the Nitro-Phospho Corporation of Richmond, Va., and Ocala, Fla.

It consists of a mixture of ground phosphate rock and prepared muck or humus, with a little wood ashes and free sulphur added. The prepared muck is inoculated with the azotobacter class of nitrogen fixing organism.

The analysis of Pho-pho-Germ shows the materials to have the following composition:

Water	12.24	12.24
Total Phosphoric Acid.....	8.75	
Equivalent to Tricalcium Phosphat.....	19.11	19.11
Insoluble Phosphoric Acid.....	8.40	
Available Phosphoric Acid.....	0.35	
Water Soluble Potash.....	0.17	
Equivalent to Potassium Carbonate.....	0.25	0.25
Total Carbon Dioxide.....	2.88	
Carbon Dioxide Combined with Potash.....	0.08	
Calcium Carbonate	6.36	6.36
Equivalent to Lime, CaO.....	3.56	
Free Sulphur	0.19	0.19
Total Nitrogen	1.30	
Insoluble Nitrogen	0.63	
Available Nitrogen	0.67	
Availability of Nitrogen.....	51.50	
Total Loss on Ignition.....	44.13	
CO ₂ , Sulphur, Water.....	15.23	
Organic Matter	28.90	28.90
Total Mineral Matter.....	55.87	
Acid Insoluble Matter, Sand.....	22.90	22.90
Total Acid Soluble Mineral Matter.....	32.97	
Lime, Calcium Phosphate, Potassium Carbonate	22.92	
Oxides of Iron and Aluminum.....	10.05	10.05
		<hr/> 100.00

No guarantee is made for this preparation. It is not sold for the available plant food it contains at the time of buying but on the claims that it is a "soil vitalizer," i. e., that the nitrifying organisms present will supply the needed nitrogen to all kinds of field crops—corn, cotton, potatoes, etc., and incidentally will render available for the plant insoluble plant food locked up in the soil.

The organisms concerned here are different from the nitrifying organisms found on the roots of legumes and which do not live apart from them.

The group which is contained in Phos-pho-Germ can fix nitrogen independently of the higher plants and this process is called azofication.

There are several scientific facts that the manufacturers and sellers of this material take advantage of, and in selling use as means to convince the prospective buyer. They have cleverly taken extracts from scientific studies and letters from scientific bureaus and, using them in a different connection, make them appear to mean that these bureaus approve of the material they sell.

Phos-pho-Germ contains the *Azotobacter* group of nitrifying organisms and it is upon these organisms that the value or non-value of the preparation depends. It is a scientific fact that this group does live and thrive under certain very narrowly fixed conditions which will seldom, if ever, be found in the field.

They require for their nutrition practically the same chemicals as do the higher plants, i. e., carbon, hydrogen, oxygen, nitrogen, phosphorus, potash, magnesium and iron. The manufacturers of Phos-pho-Germ have supplied all of these substances as can be seen from the analysis, but there are other conditions that must be regulated, and which they cannot control, before inoculation can be applied to general field crops successfully.

A suitable environment is imperative before the azotobacter group will grow. There must be suitable temperatures, season, moisture, aeration, food, and soil neutrality before they can grow.

It would be foolish to expect all these conditions favorable to growth to be generally found on our types of soil. If they are not found, then Phos-pho-Germ loses its value.

I will outline the reasons briefly why azotobacter cannot thrive on the average, ordinary farm lands of Georgia, yet the Nitro-Phospho Corporation claim that in most cases they have been successful on all types of soil.

Soil acidity is very fatal to the existence of azotobacter. Nearly all Georgia soils are acid. The slight amount of carbonates in the Phos-pho-Germ cannot correct the acidity of a soil to which it is applied because of the minute proportion to the soil body. If the organisms die, the Phos-pho-Germ loses its value.

The soil must be rich in organic matter or humus before azotobacter can live. The humus in the Phos-pho-Germ is sufficient to keep the organism alive in the preparation itself, but even if as much as a ton per acre were used, the amount of humus per square foot would be almost negligible. Even if the soil acidity were low, this deficiency of humus would be the limiting factor in their growth.

Georgia soils are poor in humus as a general rule.

Bertholet, Koch, Stranak, Lohnis, Pillai and others have shown that azotobacter have large energy requirements. In fact, they have larger energy requirements than any other form of bacteria and these requirements have to be met by the humus, pentosans, etc., of the soil. They use this material to build nucleo-proteins and phospho proteins in which their bodies are extremely rich.

Greaves states: "If the same quantities of carbohydrates per unit of nitrogen fixed be required under material conditions as are found necessary in laboratory experiments, enormous quantities would be required for the fixation of any considerable quality of nitrogen."

Georgia soils do not contain sufficient carbohydrates to supply the needs of these bacteria.

Mr. C. R. Clark, the bacteriologist of this laboratory, upon making an examination of Phos-pho-Germ made the following report:

Mr. W. C. Dumas, State Chemist, Atlanta, Ga.:

Dear Sir:—I hand you herewith report of bacterial findings and conclusions on sample of Phos-pho-Germ.

Laboratory tests showed the material to contain a mixture of bacteria, molds and spores.

To inoculate a soil is to infect it with some foreign material and just as one may infect his soil with good seed, bad seed or weed seed, so may he inoculate it with good, indifferent, or injurious bacteria. It is probable that there are as many species upon it and their usefulness to man varies in about the same ratio, therefore, many forms may be classed as bacterial weeds. The most helpful of all soil bacteria are those possessing the ability to combine the free atmospheric nitrogen with certain substances in their bodies, thus making

it available for plant use when the cell finally dies and decomposes.

Such forms are classified as nitrogen fixing bacteria and are divided into two great classes, the Symbiotic and the Non-Symbiotic nitrogen fixing bacteria.

Science, experiment, and practice have given us the symbiotic bacteria for legumes, but none for cotton, corn, wheat, potatoes, etc.

It is but natural in this period of extreme nitrogen shortage that every effort be made to increase by every possible means the present supply in the soil and to conserve that which is already present. Doubtless many preparations will appear in the market similar to the one above, claiming to increase the available supply of nitrogen in the soil through bacterial action.

The prospective purchaser should be warned that the inoculation of the soil with nitrogen fixing bacteria other than those producing nodules on the roots is extremely questionable and the purchase of such material should be made only under written guarantee of the results.

The claims for Phos-pho-Germ are largely inferred, but there is no panacea for all the farmers' troubles in regard to permanent fertility of soil from the nitrogen standpoint.

Reviewing the claims, both absolute and indicated, of Phos-pho-Germ makes me believe that the producers of this material are wilfully abridging limited scientific success with yet unattained ideals in a subtle and deceptive manner for exorbitant profit and questionable results of their product.

Very respectfully,

C. R. CLARK, Bacteriologist.

Since the discovery by Beijerinck in 1901 of the azotobacter group, many experiments have been made in an effort to make a preparation suitable for application to general crops.

Caron was the pioneer and produced a substance called "alinit" which was to be sold to farmers. This was an absolute failure.

Much work is being carried out now on this problem, but with little success. Since Beijerinck's discovery and Caron's failure with aerobic nitrogen fixers, the hope still survives that the nitrogen fixing problem in agriculture will be solved.

Many similar preparations to Phos-pho-Germ have been offered. Russell studied a preparation called "humogen" and concluded that—"There is no evidence that it possesses any specific agricultural value. There is nothing to indicate that it is any more effective than other organic manures of the same nitrogen content."

Greaves at the Utah Station says in regard to soil inoculation with non-symbiotic bacteria, "Soil inoculation in order to be successful must be accompanied by the rendering of the physical and chemical properties of the soil ideal for the growth of the specific organism to be added. A few organisms placed in a new environment which already contains millions can never hope to gain the ascendancy over the organisms naturally occurring in the soil, for they have been struggling for countless generations to adapt themselves to the environment and only those that are fitted have survived. It would appear that to ever make soil inoculation a success the chemical, physical, and even the biological conditions must be made suitable for the growth of the specific organisms added. Further, strains of the organisms must be used which have evolved under similar climatic conditions."

The Maryland Experiment Station has made thorough examinations of the so-called "allcrop inoculation" and the conclusions from both laboratory and field tests are that these preparations are ineffective.

Next comes the question of the money value of Phos-pho-Germ. I understand that the material is being offered to the farmer at \$45.00 per ton. The actual plant food as found from the analysis is valued at \$7.23 per ton of Phos-pho-Germ. Allowing an average charge of \$7.00 per ton for handling, sacking, etc., which figure will cover these charges at the present time, we get a value of \$14.23 per ton.

This figure does not include the value claimed for the organisms. However, the Georgia Department of Agriculture sells legume bacteria for \$0.30 per acre and commercial concerns for \$1.50 per acre. The azotobacter bacteria can perhaps be prepared just as cheaply, so adding the very maximum to the above price per ton, we get as a value \$15.73 per ton. These values it seems to me are already generous but even placing the value at \$20.00 a ton, the price the Nitro-Phospho Corporation asks for their product is out of all bounds.

The following chemists of this laboratory made the examinations and analyses reported: L. W. Bradley, L. L. Baker, Chas. Buchwald, C. R. Clark and W. C. Dumas.

In conclusion, I want to make for the benefit of the farmers a brief summary in reference to Phos-pho-Germ.

1. The material will not do what is claimed for it under average field conditions in Georgia.
2. The material has a limited value under special conditions favorably regulated.
3. The price charged for Phos-pho-Germ is excessive.

4. The Georgia farmers should make inquiries of the Department of Agriculture before buying any new fertilizer material, the value of which has not been fully established.

I respectfully submit the above report to you for whatever action you see fit to take in the matter and in doing so I urge you to take steps to protect the farmer so that he will not become the victim of the clever selling of an article under greatly exaggerated claims.

Respectfully submitted,
(Signed) W. C. DUMAS,
State Chemist.

March 29th, 1919.

Editor Journal of the American Peat Society:

Dear Sir:—As I wired you Thursday, your letter of March 24th was forwarded to me to Richmond and unfortunately did not reach me until the afternoon of the 27th, obviously too late to have a reply in your hands for consideration the 28th.

The State of Georgia is not in the territory in which the American Nitro-Phospho Corporation is licensed to manufacture and sell Phos-pho-Germ, but the report of the Agricultural Commissioner of that State is, of course, of vital interest to all its users and manufacturers.

The inventor of Phos-pho-Germ is Dr. G. H. Earp-Thomas, whose standing as a bacteriologist is generally recognized throughout the United States and other countries and needs no introduction.

When he first put on the market Farmogerm for the inoculation of legume seeds, the idea was ridiculed by many and there were charges of fraud by several state agricultural departments and by other authorities on agriculture. The practicability of seed and soil inoculation of legumes is now universally recognized, however, and many State Agricultural Departments as well as the Federal Agricultural Department are now distributing legume cultures—many made under Dr. Thomas' direction.

Phos-pho-Germ is one step in advance. The opposition, which we assume comes from persons who are honest in their conviction that the inoculation of soil with nitrifying and other bacteria beneficial to all crops is not practicable, is not so general nor so radical as was directed against Farmogerm when first placed on the market.

After all, the proof of the worth of Phos-pho-Germ is in the results obtained from its use. It has been tried in the northern as well as the southern states with remarkable success and we are prepared to submit testimonials from hundreds who have used it with most satisfactory results. The

number of "repeat" orders received this year tells the story of the work it does.

In all of the advertising put out by the manufacturers of Phos-pho-Germ, the discontinuance of the use of chemical and other fertilizers has not been recommended but only the purchase of enough Phos-pho-Germ to test its worth along side of such fertilizers. Nothing could indicate more clearly the faith we have in the work Phos-pho-Germ will do and we cannot believe it is entirely fair for any State Agricultural Board to send out a derogatory report without having tested it in the soil nor having investigated the results obtained by farmers who have used it in their state.

The protection of the farmer, of course, should be the first consideration of the Agricultural Commissioner of any state, but we submit that if any progress is to be made in better methods of crop growing, new discoveries will be made—without them there can be no progress. The principal value of Phos-pho-Germ lies in the bacterial action, not chemical, which is a new idea and its use should not be condemned by anyone until thorough testing proves it is not what is claimed for it.

A copy of a statement from Dr. Thomas is enclosed which answers more specifically the report referred to.

Assuring you of the appreciation of the American Nitro-Phospho Corporation and other manufacturers of Phos-pho-Germ of the opportunity to say something in reply to the criticism made, we are

Very sincerely,
AMERICAN NITRO-PHOSPHO CORP.,
By G. M. Craig, General Manager.

Richmond, Va., March 28th, 1919.

American Nitro-Phospho Corp.,
80 Lafayette Street,
New York City,
Gentlemen:

In reference to report of State Chemist of Georgia on Phos-pho-Germ: I find that he has come very close to a genuine analysis of Phos-pho-Germ, from a chemical standpoint. It does, however, contain other elements in quantity suitable for the pabulum or food of the various sixty-five varieties of beneficial soil bacteria with which it is inoculated, and which are essential for the success which has been universally obtained by the farmers as reported to us from the various sections in which it has been tried.

The Bacteriological report is very incomplete and harmful to the manufacturers for it does not go far enough, as the Chemical report does, in showing the analysis of the bacterial content of the mixture. If it had it would have shown that Phos-pho-Germ contains bacteria of many varieties including Legume bacteria, Azotobacters of many varieties, some domestic and some foreign, some which work under varying conditions of soil such as reaction and temperature—and other acid producing bacteria, which have a direct effect in making soluble the materials which the Chemist so ably reports on.

Had both reports been complete they would have shown that Phos-pho-Germ carries micro-organisms in an insoluble, or slowly soluble, chemical and organic mass, and that by their growth and development they convert as plant food in their life process, the material in which they are surrounded, or they would cease to exist. They are entirely dependent for food upon the insoluble matter as described by the Chemist and if they remain alive they certainly can only do so by using this as food, and as they are protoplasmic in nature and give off surplus products, it is evident that the plants find such products a highly desirable combination for their food and development. Laboratory tests show over twenty billions of living bacteria per gram of Phos-pho-Germ.

From a chemical standpoint Phos-pho-Germ perhaps does not have greater value than claimed by the State Chemist, but from the bacterial standpoint the State Chemist is in no position to pass judgment and the State Bacteriologist has evidently made but a very superficial examination of the material. This is highly evident from that fact that he was only able to identify one variety or strain of Azotobacters, or independent nitrogen fixing organism, evidently overlooking all the other varieties as herein mentioned, besides the different strains of Azotobacters with which Phos-pho-Germ abounds. Any complete bacteriological examination will prove this great variety of organisms to be present.

The State Chemist in his report admits the presence of nitro bacteria, and the ability of these bacteria to fix nitrogen in the soil, but his principal point at issue seems to be whether or not these organisms will thrive under the varying soil conditions. The point is well taken, and the difficulty was recognized by us years ago in our early researches. The problem was solved by securing the various strains of bacteria which live under the varying soil conditions described.

In carefully checked experiments carried on over a period of two years under a great variety of soil and other conditions, including tests in foreign countries, we found in every case that the bacteria could be depended upon to develop and pro-

duce results. However, we are willing to admit that under very unfavorable soil conditions a satisfactory result might not be obtained without using an unprofitable amount of Phos-pho-Germ necessary to overcome it. Such soil conditions are rarely found and need little consideration in the total results.

No attempt in advertising has been made by the use of extracts from any scientific publications to claim endorsement of Phos-pho-Germ, but such extracts have been used to show that the bacteria processes are well established from a scientific standpoint by independent workers.

The statement that Phos-pho-Germ is entirely dependent for its value or non-value upon *Azotobacters* is erroneous, as other bacteria in it are of equal, if not more value inasmuch as they make available the insoluble compounds in the material and in the soil.

Tests thus far conducted in acid soils as found in Georgia and Virginia have shown *Azotobacters* in Phos-pho-Germ to be active and producing results.

Few cultivatable soils contain insufficient humus (vegetable matter) from previous crops to provide bacterial food with such additions as are included in Phos-pho-Germ and we have provided other means in the material to take care of this need.

We see absolutely nothing to warrant the statement made in the final paragraph in the report of the State Bacteriologist that in his belief the manufacturers of Phos-pho-Germ are in fact using deceptive means to sell their product. Investigations of the results obtained through the use of Phos-pho-Germ sufficiently contradict any such imputation. Men of undeniably high standing became interested in the manufacture of Phos-pho-Germ and supported it financially after careful investigation and experiments carried over a sufficient period to justify them in their confidence.

The claim that Phos-pho-Germ is being sold at an exorbitant price is incorrect, and careful investigation will so prove.

Very truly yours,

G. H. EARP-THOMAS.

INVESTIGATION OF PEAT BOGS IN CANADA*

A. Anrep.

In accordance with instructions, a survey of peat bogs was carried on during the season of 1917; in order to determine the extent, depth, and different qualities of the peat contained in the various bogs.

*Reprint from Summary Report, Mines Branch, Ottawa, Can.

This investigation started in the middle of June, when the writer left Ottawa with Mr. A. R. Whittier and Mr. P. Bissonnette as temporary assistants, to perform the field work, which was carried on during part of June, July, August, September, and part of October.

The following statement summarizes briefly the results of the season's investigation:—

(1) Girard peat bog, situated about $1\frac{3}{4}$ miles northwest of Girard station, and approximately 8 miles south of St. Johns, in the counties of St. Johns and Napierville, Province of Quebec.

The total area covered by this bog is, approximately, 3,104 acres, with an average depth varying from 3 to 12 feet.

The larger portion of the southern part of the bog is very well suited for the manufacture of peat fuel. It is fairly well humified, with cohesive properties, and has a considerable depth.

While the investigations were being conducted at Girard, I made a preliminary investigation of Pont Rouge peat bog, to ascertain the quality and average depth of the bog, in order to give an opinion regarding the suitability of the bog for the erection of a peat fuel plant. Later on in the season, a proper survey was made of the bog by Messrs. R. S. & W. S. Lea, Consulting Engineers, of Montreal. At that time I also had an interview with Mr. Chas. Staff, Secretary of the Larrowe Milling Company, Detroit, Mich., U. S. A., for the purpose of giving them advice in regard to the erection of a peat litter plant near St. Stephen, New Brunswick.

At the end of July the entire party moved to New Brunswick, where the following bogs were investigated:—

(2) St. Stephen peat bog is situated about 4 miles north of St. Stephen, in the parish of St. Stephen, county of Charlotte, New Brunswick.

The total area covered by the bog is 153 acres; which contains two kinds of peat, namely, peat litter and peat fuel.

The peat litter bog consists, approximately, of 71 acres, with an average depth varying from 12 to 30 feet.

The remaining 82 acres represent peat fuel, with an average depth varying from 3 to 12 feet.

The larger part of the bog, with the exception of the northern and southern bays, and a strip of 200 to 400 feet wide around the margin of the bog, is fairly free from humus, and will produce a high grade peat litter.

(3) Hayman peat bog is situated about 6 miles north of St. Stephen town, in the parish of St. Stephen, county of Charlotte, New Brunswick.

The total area of this bog is, approximately, 58 acres, with an average depth varying from 3 to 17 feet.

The area of this bog is too small for a large peat fuel manufacturing plant; but the considerable depth of the bog increases the quantity of the fuel contents, and, by laying out the working field systematically and with great care, this bog can be utilized for the manufacture of machine peat on a small scale.

(4) Seely Cove peat bog, situated 4 miles southwest of the road from Pennfield station, in the parish of Pennfield, county of Charlotte.

The total area covered by this bog is, approximately, 123 acres; which contains two kinds of peat, namely, peat litter and peat fuel.

The peat litter area occupies the centre of the whole bog, and consists approximately of 49 acres, with an average depth varying from 12 to 20 feet.

This portion of the bog is very little humified. It has a considerable depth, which will produce a good peat litter suitable for bedding, packing, etc. The remaining 74 acres of the bog consist of peat fuel, with an average depth varying from 3 to 7 feet. As the area is very small, but the peat therein very well humified, it would produce fairly good hand-made peat fuel for domestic purposes.

(5) Pennfield peat bog, situated about 4 miles south of St. George, about $4\frac{1}{2}$ miles north of Pennfield station, and about $1\frac{1}{2}$ miles from Pennfield post office, Charlotte county.

The total area covered by this bog is, approximately 680 acres, with an average depth varying from 3 to 8 feet. This peat is practically formed of sphagnum mosses, is practically free from humus, and would produce high grade peat litter; but the bog is not suitable for the manufacture of peat litter on a large scale, as the area is not sufficient. Farmers, however, could cut it by hand and utilize it for stabling purposes, etc.

(6) Hunter peat bog, situated about 3 miles northeast of Pennfield station, Charlotte county.

The total area is, approximately, 95 acres, with an average depth varying from 3 to 10 feet.

The peat in this bog is fairly well humified, uniform in quality, possesses fairly high cohesive properties, and is of a sufficient depth to justify the erection of a small modern peat fuel plant.

(7) Pocologan peat bog, situated about 5 miles northeast of St. George, and about 4 miles south of Pennfield station,

and at certain points the Canadian Pacific railway traverses the eastern part of the bog.

The total area covered by this bog is, approximately 352 acres: which contains two kinds of peat, namely, peat litter and peat fuel.

The peat litter area covers several centrally located sections of the bog, and consists approximately of 107 acres, with an average depth varying from 12 to 16 feet.

The peat litter formation is situated on the top of the fuel of this bog, and forms 5 separate hillocks: one of which is located in the northern portion of the bog; the largest is in the west part of the bog; two are situated in the centre of the bog; and one in the southern portion.

This peat is principally formed by sphagnum mosses, is practically free from humus, and would produce a good peat litter.

The remainder of the area, 245 acres, is of the nature of a peat fuel, with an average depth varying from 5 to 7 feet. The peat in this part of the bog is fairly well humified.

As this well humified area is very much cut up by the occurrences of peat litter, it is not suitable for the erection of a modern and commercial peat fuel plant.

(8) The Musquash peat bog, consisting of one large and three small bogs, are situated about 2 miles east of Prince of Wales station, and about 12 miles west of St. John city, New Brunswick.

The larger part of bog No. 2 is located in the parish of Musquash; the remainder in the parish of Lancaster, county of St. John.

Bogs Nos. 3 and 4 are in the parish of Lancaster, county of St. John.

The total area covered by bog No. 1 is, approximately, 300 acres. The total area covered by bog No. 2 is, approximately, 8 acres. The total area covered by bog No. 3 is, approximately, 29 acres. The total area covered by bog No. 4 is, approximately, 25 acres.

As the three bogs are scattered, and each bog is of a very small area, they are not suitable for the manufacture of peat litter on a commercial scale.

Bog No. 1 has an average depth varying from 3 to 14 feet. The peat is practically free from humus, and would produce suitable peat litter.

From October 20 to November 2, preliminary investigations were made of the peat bog near Cochrane, Ontario. The Cochrane bog is situated about 1 mile south of Cochrane station, in Lamarche township, probably continuing into St. John

and Hanna townships, county of Timiskaming, Ontario, and runs in a north and south direction.

The total area of the bog of which a preliminary investigation was made is, approximately, 1,400 acres, with an average depth varying from 4 to 21 feet.

At the same time drill holes were made in the bogs south of Cochrane, at the following mileage: 239, 240, 243.

The formation of these bogs is very similar to that of the bog near Cochrane, but the disadvantages of these peat areas lie in the fact that the surface is very heavily wooded, the clearing of which would involve expenditure at present.

The total area investigated in the Provinces of Quebec, New Brunswick, and Ontario during the season of 1917 comprises, approximately, 7,115 acres.

MINNESOTA PEAT ACTIVITIES.

The Government reported recently that there is \$20,000,000 worth of peat in Minnesota, which State is reported to contain the largest amount of peat in the United States.

Minnesota State Auditor J. A. O. Preus has been very active in endeavoring to have the peat deposits properly surveyed.

In the latter part of January the State Land Improvement Board of Minnesota decided to ask its legislature for sufficient funds to make a survey and investigation of the State peat beds.

J. A. O. Preus, State Auditor, was in Washington early in February conferring with Director Van H. Manning of the U. S. Bureau of Mines, and it is reported that he was assured that the Federal Government would send experts to Minnesota, to assist in the survey, if the State would appropriate funds to help defray expenses.

PEAT WOOL—A SCANDINAVIAN FIBRE SUBSTITUTE.

On the initiative of Professor G. Sellegren of the Technical High School at Stockholm, the question was taken up for the investigation of Peat Fibre, and this has given such results that a stock company has been formed under the name of "Fiberuld," the Swedish nomination for the new material. This company is now equipping a factory at Hadenge in Joakoping Len for spinning fibre of peat taken from the large bogs there. After many experiments an economical method of extracting peat fibre or peat litter has been worked out. The fibre obtained will be dealt with further, carded, spun, and woven in a factory which the company is establishing near Goteborg. The peat wool can be made into mating, carpet

stuff, etc, in various colours, while by mixing in 10 per cent. of animal hair it can be used as felt soles in footwear. The most surprising development is the weaving of cloth, in order to do which 30 to 40 per cent. of wool is mixed in. This product can hardly be distinguished from cloth made from wool alone, so soft is the feel of it. The strength is such that white wool thread can bear 9 kilos (19.8 pounds) the fibre-wool thread can bear 13 kilos (28.7 pounds) which also shows that the fibre-wool is usable for binder twine.

AMERICAN PEAT FUEL CORPORATION.

A company under this name has been incorporated under the Laws of the State of Delaware with \$500,000 capital for the purpose of acquiring peat bogs for mining peat fuel etc. The incorporators are Michael S. Donovan, Detroit, Mich.; Earl N. Smith, Lansing, Mich.; Malcolm C. Ever, Birmingham, Ala.

PEAT COKE AND OIL SYNDICATE.

At the annual meeting held in London, England on Dec. 5th. last, J. W. Leadbeater, Chairman, said that the syndicate was established to work out a process for the production of a good coke or smokeless fuel from peat, with by-product recovery. One complete gas plant had been adapted to the process, and it was intended to bring others, now under option, into operation as soon as possible. At the present time the syndicate was renting spare plant at two gas works. The decolorizing agent obtained as a by-product had been very favorably reported upon. The coke employed in the process, in conjunction with peat, was the very smallest gas coke, and these with a certain binder, made an excellent but not a smokeless fuel, which was now being sold at \$10 per ton at the works. No special retorts have been used up to the present, the carbonization being effected at a low temperature.

C. A. WILLMARTH COMPANY.

The Process Fuel and Machinery Company of Detroit, Mich., have changed their name to C. A. Willmarth Company, Designers and builders of peat fuel, coke, mull and litter machinery, 416 Buhl Block, Detroit, Mich.

PEAT AS AN ALTERNATIVE FOR LOW-GRADE FUELS.

Scarcity of coal in Great Britain, due to the absence of miners at the front, has raised the question of coal substitutes, and peat is mentioned as a suitable alternative for low-grade fuels. Peat deposits in England, Scotland, and Wales have re-

mained almost untouched because of the low price of coal, but war conditions, necessitating, as they have, the restriction of coal supplies, bring the possible utilization of peat to the fore.

According to the estimates of engineers who have studied the matter, available low-grade fuel in the form of peat is greater than all the world's sources of coal. In the United Kingdom the peat area is estimated at 9,400 square miles, while that of Canada is 37,000 square miles, of an average depth of 6 feet. Of this vast area, 12,000 square miles are located in the central Provinces and represent the heating equivalent of 5,000,000,000 tons of anthracite.

It is reported that the Canadian Government has directed its attention to the development of peat, and its Department of Mines has, within the last 10 years, mapped out 58 Canadian peat bogs conveniently situated with respect to inhabited and industrial centers.

Disadvantages of Peat—Direct Combustion.

There are disadvantages in the use of peat, and these are its bulky nature and the great quantity of water it contains. While 1 cubic foot of anthracite weighs 56 pounds, the same volume of machine-pressed peat weighs only 27 pounds; and inasmuch as the heating value of anthracite is about 1.8 times that of peat containing 25 per cent of moisture, the heat value of equal volumes are in the proportion of nearly 4 to 1, which factor tells seriously against both transportation and storage. Fresh peat contains from 85 to 90 per cent of water, which, by drying, can be reduced to 25 per cent, or even less. Two typical samples of peat gave on analysis: Moisture, 17.2 and 19 per cent; volatile matter, 51 and 55 per cent; fixed carbon, 24.8 and 25 per cent; ash, 7 and 1 per cent.

For direct combustion peat has long been used. Drained peat deposits are roughly cut and then allowed to dry in the hot sun, after which they are ready for winter consumption. Many and various attempts have been made to dry peat artificially, but it is believed that it may become of vast industrial utility by the primitive and more economic method of sun drying. In its partially dried condition, costing very little, peat may be used industrially in the form of powder. Peat may also be used for the manufacture of producer gas. It is interesting to know that a large station in Wiesmoor, in Germany, has worked for many years with air-dried peat and has proved so successful that the station distributes electrical power within a radius of 25 miles. Of course, this has required the use of a special plant.

In the modern development of powdered fuel, peat has not been overlooked. Air drying can be carried out to an extent

which allows for pulverization. The product is then screened and dried down to 15 per cent in rotary driers. While not in extended use at present in this form, the experimental work that has been carried out gives indication of its possibilities as a fuel for boilers, cement kilns, metallurgical furnaces, and even locomotives. As a boiler fuel it gives a very good yield of steam. With 15 per cent of moisture and a dry caloric value of 10,000 B. t. u. per pound, it still possesses 8,000 B. t. u. available for external heating.

Peat as a Source of Producer Gas.

As a source of producer gas peat has proved quite a success. In this case, one great difference between peat and ordinary producer fuels lies in the high moisture content and the greater proportion of carbon dioxide in the gas produced, owing to lower temperature of the reaction in the generator. On this subject an engineer's report states:

Otherwise the moisture presents no serious obstacle, but the working of the generator should admit of such elasticity as will be required for the varying amounts of moisture usually occurring in this type of fuel. The high proportion of carbon dioxide—up to 10 per cent—need not interfere, if the proportion of combustible constituents is still good, except that it represents a large proportion of the carbon of the fuel in a completely burned form, and therefore of no further service as a power producer. The usual composition of producer gas from peat shows carbon dioxide, 10 per cent; carbon monoxide, 10 to 20 per cent; hydrogen, 6 to 13 per cent; methane, 3 to 6 per cent; and nitrogen, 60 per cent. Slight modifications of the generator admit of a wide difference in the moisture content of the peat, and it is said that peat containing 60 to 70 per cent of moisture has been successfully gasified.

A difficulty, however, attaching to the gasification of peat is that of tar scrubbing. Coke scrubbers soon become clogged, and tar passes through the pipes and reaches the engine valves, necessitating frequent cleaning. This difficulty is overcome by abundant spraying with water, after which a centrifugal extractor effects a sufficient separation, and though less frequent cleansing is then necessary it is still advisable to err on the side of too frequent cleaning.

Recovering of Ammonia and Nitrogen—Other By-Products.

The same engineer continues with regard to the recovery of ammonia from peat:

A by no means unimportant feature of peat gasification arises from its comparatively high nitrogen content. This not infrequently reaches 2 per cent of the total dry weight. It may, therefore, become a valuable source of ammonia and other

nitrogen compounds. As an example, 13 bogs in the Province of Ontario gave an average nitrogen content of 1.3 per cent on the basis of 25 per cent moisture. The total amount of peat of these bogs is 43,000,000 tons and the nitrogen content 500,000 tons, equivalent to 1,800,000 tons of ammonium sulphate with present-day efficiency of recovery. In some practice the recovery of this sulphate becomes the chief aim, the values derived therefrom covering the total cost of operation, leaving the gas as a cheap by-product, and the profits increase rapidly with increasing nitrogen content and recovery efficiency. Peat may thus become a source of one of our most important fertilizers, the value of which can not be ignored in these days of increasing agricultural activity, and the large demand for home-produced fertilizers.

By a system of coking, too, other valuable by-products in large demand are obtainable, among which are illuminating and lubricating oils, acetic acid, methyl alcohol, carbolic acid, and paraffin; but the possibilities of such applications and the methods best suited to the most successful commercial results, will demand the closest research on a large scale by peat specialists, and are problems which can not be easily tackled and solved by those without the highly specialized knowledge and experience of the behavior of this substance in all the processes from the cutting of the bog to the last stage of utilization.—(Consular Report).

ALCOHOL FROM SWEDISH WHITE MOSS.

The County Syndicate Aktiebolag, has petitioned the Swedish Government for permission to make 5,000,000 liters (1,321,000 gallons) of alcoholic spirit from white moss, of which there are enormous quantities available. The quality of such alcohol is said to be very good, and its cost less per liter than spirit made from grain or potatoes. It can be easily denatured.

The petition proposes that the alcohol be manufactured under official supervision and that the Government be taken in as partner.—(Consular Report).

ALCOHOL FROM LAVA AND PEAT.

The present shortage of alcohol, especially for motor boats, gives special importance to the new method for extracting alcohol from peat and lava. Though lava was used for this purpose in the middle of last century when the potato crop failed, it has since then been neglected.

Peat is found on thousands of hectares and at a depth of 7 to 8 meters (22.96 to 26.25 feet). From 100 kilos (220 pounds) of dried peat substance about 6 liters (1.58 gallons) of 100 per cent alcohol can be obtained. This is about the same yield as potatoes.

The method of extracting alcohol from peat is about the same as by sulphite. The peat is boiled under pressure with sulphuric acid, by which a sugar solution is obtained and some residue products. After the acid has been neutralized with lime, the sugar solution is made into alcohol, the peat residue being collected and made into briquettes for fuel.

The experiments made with regard to this method of extracting alcohol have been successful, and the Swedish Government has agreed to the building of a factory on the basis that the shareholders in the company should have the right to purchase and use the alcohol for their motor boats, trucks, and private automobiles irrespective of Government prohibitions and maximum prices.—(Consular Report.)

(The inclusion of the word lava in this report no doubt is an error, as its use will in no way enhance the production of alcohol.—Editor).

GERMANY USES PEAT FIBER.

Peat fiber belongs to the most interesting discoveries in the field of substitute textile raw stuffs. This cannot, however, be practically used without mixture with other kinds of fiber. A mixture of 50 per cent peat fiber and 50 per cent wool gives, according to the opinion of German experts, a very strong and durable material that looks extremely well and is excellent for men's clothing. The valuable qualities of peat fiber, however, are limited by the difficulties in procuring the peat. Only the younger moss turf, called "Grantorf," contain some 8 per cent of the "curls" which can be employed in spinning. The black peat (used for burning) cannot be employed. The production from about 5,000,000 double hundredweights of peat amount to about 100,000 double hundredweights of fiber; in other words, a very small amount, when the labor as well as the actual yield are both taken into account.—(Consular Report.)

PEAT FIBER IN SWEDEN.

Government experts are examining peat with the view of using peat fiber for textiles. As the result of a Goteborg factory's experiments with the fiber for proof paper, box board, and darning yarn it has been concluded that this product is

much inferior to cellulose for the purpose named. The Swedish machines are not suitable for working peat fiber.—(Consular Report.)

PEAT BRIQUETS IN DENMARK.

Mr. H. Nielsen, of Esbjerg, Denmark, has invented a machine for mixing peat and brown coal for briquets, which are said to contain 6,000 heat calories, only 1,004 less than in good steam coal. The mixture is one-third brown coal and two-thirds peat, with a little pitch or tar to make it stick together. It is the intention to build half a dozen factories in various parts of the country for the utilization of this invention, which has been sold to Messrs. Sogaard and Bethelsen, of Aalborg and Aarhus, respectively.—(Consular Report.)

EXTRACTING KAURI-GUM OIL IN NEW ZEALAND.

Kauri gum has been exported from New Zealand to the value of \$100,000,000, which does not seem to represent one-half of the actual value of the gum deposited in the earth from the immense kauri forests that have covered much of the northern half of the north island for many centuries. It is claimed that there are many thousands of acres of rich kauri peat lands that will yield from 5,000 to 6,000 tons of chip gum dirt, said to have a value of at least \$5 per ton, or from \$25,000 to \$30,000 per acre, net, to say nothing of the standing timber and the many buried trunks of kauri trees very rich in gum.

This kauri peat has been successfully treated by distillation, according to an article published in the New Zealand Farmer of this city, when tried in a small way, and now plans are being prepared by a consulting engineer for a plant with a capacity of 4,500 gallons of kauri-gum oil per week, to cost with necessary accessories about \$40,000. It is claimed this oil is worth 48 cents per gallon clear of all costs in Auckland. It is claimed additional units of this plant could be built at about one-half of the cost of the original works.

Results of Operations on Virgin Kauri-Gum Lands.

The following extract is taken from an article in the issue of the New Zealand Farmer of this city, giving an account of the test working of a 7-acre tract of virgin kauri-gum lands, and an estimate of the oil contents held in the peat in sight:

This particular property gives a demonstration of the following facts: Seven acres of swamp have been worked and "faced" (that is, turned over) for a depth of 9 feet, by the labor of 15 men, in 16 months, and large gum to the value of

£5,701 (\$27,744) has been extracted from that area and sold, while in addition 5,800 yards of chip dirt have been dug and stacked on the bank. The net value of the chip dirt is placed at 20s. (\$4.87) per ton, so that the 5,800 tons would be worth £5,800 (\$28,226), and the total value of the gum taken from the seven acres is £11,501 (\$55,970). But this 6,000 tons of chip dirt we find is worth 75 gallons of oil per ton, and should yield a total of 450,000 gallons, and the net value of this soil, after paying manufacturing, packing, and carting to ship's side is 2s. per gallon (\$0.48), or for the total oil value £45,000 (\$218,993).

In explanation of the above it should be understood that the heavy kauri forests in these parts of New Zealand have been shedding this gum in abundance for centuries from the leaves, limbs, and the body of the tree, and much of it is buried as low as 8 to 10 feet below the surface, and during the ages large quantities of the gum have chipped off and decayed to some extent and formed immense peat deposits wherever sufficient water was found, that are now rich in kauri oils and lighter spirits. According to late developments this is destined to become an important industry in this part of the Dominion, for it is claimed that the oil can be profitably used in the manufacture of varnish, paints, etc.—(Consular Report.)

A considerable trade is being done by certain New Zealand companies in the preparation and export of kauri gum, and since 1914 two important processes—one for entirely freeing the gum from dirt, the other for utilizing a greater percentage of the oil which has always been known to exist in the dirt in which the gum is embedded—promises to increase its importance.

According to the latest report issued by the Government's superintendent of the industry, the chief market for the gum now is the United States, but before the war Germany was a steady buyer of even the lowest qualities. At present Japan is showing some interest in the gum. The quantity exported to all destinations in 1916-17 was 4,862 tons, valued at \$1,461,268.

Purifying the Gum—Extraction of Oil.

In 1914 the Dominion Government appointed a superintendent for the industry, and in 1917 the Government analyst succeeded in discovering a method for separating the dirt which, until his experiments, had detracted from the quality and value of the finished product. The first step in this new method of treatment is to immerse the gum, mixed as it is

with dirt, in a strong solution of common salt. Apparently the salt has no other function in the process than to increase the specific gravity of the liquid, and so to increase its floating power. The gum will float in the solution and the greater part of the dirt will sink. A certain quantity of the dirt still remains afloat, as it is porous and contains air bubbles. The problem of getting rid of the air, and so cause this dirt to sink, is solved by vacuum treatment. When the air is withdrawn the dirt sinks and there is no further difficulty in removing the gum from the solution.

The second process, which has only recently been announced by one of the operating companies, is designed to extract oil from the kauri swamps on an extensive scale. This oil is to be found in the layer or stratum of dirt from which "chip" gum is obtained. As kauri gum is used for varnish making, its oil content is mainly responsible for its value, but that the oil itself is very valuable is revealed in the price paid for the gum. At prices ruling in the present year the gum, which is sold at \$5 per ton at the swamps, has brought \$200 to \$250 per ton in the United Kingdom. Having formed this view (although acknowledging that the gum is also used for other purposes), the company undertook investigations to ascertain (1) the amount of oil in the dirt proposed to be treated, (2) what amount of oil could be extracted, (3) its value, and (4) cost of production.

A model working plant was made for treating the oil products, and at first only 28 gallons to the ton were secured; but after considerable experimentation a duplex system of distillation was worked out by which 85 to 90 per cent of the oil could be saved. The process is quite new and forms, it is stated, an important discovery, practically bringing most of the gum swamps of the north into oil-producing country. The process is simple, the cost of plant small, and the cost of treatment not more than \$0.08 a gallon.

Commercial Prospects.

The company claims that the results of these investigations prove:

(1) That the oil can be extracted by distillation at the small cost of \$0.08 per gallon.

(2) That the chip dirt will yield 73 gallons per ton, and selected stuff still more.

(3) That the oil, when refined and fractionized, is worth \$0.73 per gallon, making the dirt treated worth \$44 per ton.

(4) That swamps where the chip dirt has not been destroyed by fire are capable of giving 1,000 tons to the acre of

first quality—73 gallons per ton—and at least as much more of a lower value, which has not yet been ascertained.

(5) The timber from the swamp, which is very rich in oil, can be treated by the same process, and this, added to the oil from the chip dirt, will quite possibly make the yield from one acre 200,000 gallons of oil. This refers to the richer swamp land and does not apply generally.

(6) The commercial values of the oil would at the present time, owing to war conditions, be very high, as oils are in great demand; but kauri oil is something more than a mere motor or Diesel oil, and will, the company's chemists state, command a high value, even after the war, in various manufacturing industries, and will have a world-wide market. Its present valuation at \$0.73 a gallon, refined, is based on the price of similar oils now marketable in the Dominion.

With a view to developing the industry, the company is having prepared plans for a single-unit machine, which, when tried and found efficient, will be the model for a larger plant.—(Consular Report.)

EXTRACTION OF AMMONIA FROM SOIL.

A comparison was made of the amount of ammonia extracted from soils by water and by five percent hydrochloric acid. Three soils were used, a silt loam, a clay and a peat. While in no case did the aqueous extraction give the full amount of ammonia from the different soils, yet a certain relation appears to exist between the amounts extracted by the two methods. It is stated that for comparative purposes the ammonia found in aqueous extractions would be just as useful as the large amounts found by extracting the soil with five percent hydrochloric acid.—(T. E. Richmond, *Soil Science*, 1918, vol. 5, p. 481.)

LIME-PEAT COMPOST.

Rippert proposes to utilize the fertilizing substances contained in great quantities in moors and peat bogs by composting with lime the moor and peat masses. When these contain much water it is convenient to add quicklime in order to bind the excess water and to use the heat liberated by the combination to disaggregate the vegetable fibers. The ammonia produced must be prevented from escaping, as far as possible, by covering with fresh masses. The heap is allowed to lie for some time and then is turned to mix thoroughly the moor or peat soil with the lime. In this way can be made a very good fertilizer containing 20 to 40 percent lime that is very suitable for ameliorating heavy and hard clay and loamy soils. When dry

peat is used it is better to employ pulverized limestone instead of quicklime. Lime-peat compost improves the physical constitution of the soil and increases the amount of organic substances which are offered to the plants in an assimilating condition. In light as well as in heavy soils very good results have been obtained.—(Tonind, *Ztg.*, 1918, Vol. 42, p. 229.)

INFLUENCE OF CULTIVATION ON MICROBIAL ACTIVITY.

All samples taken from uncultivated, raw and strongly acid upland bog soil at depths of 5 to 20 centimeters contained microbes capable of ammonifying organically combined nitrogen. The putrefactive power of the soil is very small as a result of soil conditions and the consequent small number and effectiveness of the putrefying bacteria. The measures involved in cultivation, especially liming, brought about a very marked increase of ammonifying activity. The ammonifying power of a mineral soil used for comparison exceeded during the first year that of the more strongly limed bog soil. Nitrifying bacteria were not present in the raw, uncultivated bog soil nor during the first year in portions of it limed up to 1500 kilos lime per hectare. Liming to the extent of two tons lime per acre gave the soil a small nitrifying activity which was much less than that of the check mineral soil. Bacteria are present in the raw acid soil which can reduce nitric and nitrous salts with or without the liberation of nitrogen. Cultivation and liming increased the nitrous destroying activity in proportion to the amount of lime added. The dentitrifying power of the strongly limed soil soon corresponds with that of a mineral soil of neutral reaction rich in microbes. *Azotobacter* organisms are not present in raw acid upland bog soil nor had they colonized during the first year upon cultivated areas either weakly or strongly limed. *Bac. amylobacter* was found in all samples of uncultivated and cultivated bog soil. Tubercle bacteria were present in only a few samples of raw uncultivated bog soil. No verifiable transfer of tubercle bacteria had taken place during the course of a half year from an inoculated soil to neighboring cultivated bog areas.—(Th. Arnd. *Mitt.*, 1917, Vol. 35, p. 269.)

PEAT BRIQUETS IN IRELAND.

Arrangements are being made in Belfast to commence on a large scale the manufacture of peat briquets by a new process. Raw undried peat is mascerated in mortar mills, and a small amount of lime is added, together with a little bitumen. The mass is allowed to stand for a few hours and is then sub-

jected to hydraulic pressure, which squeezes out surplus water, giving the briquet, which after having been allowed to set for a short time, burns freely with a good flame.—(Gas J., Nov. 26, 1918.)

DISTILLATION OF HEATH SOD.

Experiments in the distillation of heath sod in France showed a yield of 23.78 percent gas and 22.84 percent charcoal (Calculated from the gross weight as delivered to the works). The gas is of good enough quality to be mixed in equal proportions with coal gas. The charcoal is of good quality, bringing 25 to 30 percent better prices than pine charcoal.—(J. des usines a gaz., 1917.)

GAS FROM PEAT.

Wood and peat differ from coal and crude oil in the high moisture content (in peat sometimes as high as 90 percent). For making gas, they should be at least as dry as ordinary air (about 20 percent moisture). Above about 280°C. the combination of wood is exothermic. Consisting mostly of cellulose and lignite, wood and peat have a high oxygen content and low calorific value. Most of the oxygen comes off as carbon dioxide and carbon monoxide, so that the gas contains 20 to 30 percent of each of these constituents. It contains only about 15 percent methane and 5 percent of heavy hydrocarbons. While it is theoretically possible to increase the heat value by passing the gas over glowing charcoal to reduce carbon dioxide to carbon monoxide, in practice there is much loss by decomposition of hydrocarbons as gain by formation of carbon monoxide. By passing the crude gas, containing tar and steam, over glowing charcoal, some water gas is obtained; but even this method does not enrich the gas sufficiently to be practicable. Better results can be obtained simply by distilling well dried material in horizontal or inclined retorts not more than half filled. If each charge is drenched with tar from preceding charges, the yield of hydrocarbons is somewhat increased. The carbon dioxide can be removed by dissolving in water under pressure, or by absorption in lime water. The coke from peat is friable and has little value. The results obtained from peat vary a great deal more than those from wood.—(E. Ott. J. Gasbel, 1917.)

DANISH PEAT INDUSTRY.

Owing to the high cost of imported coal and the difficulties of getting supplies at the high prices, the cheap fuel consumers

of Denmark have been forced to develop the native peat deposits in the central parts of Jutland. As an example of the way in which the deposits are being worked, one firm in Odense has purchased a 100-acre estate for about \$25,000 (nearly five times its pre-war agricultural value) and expects to obtain 9,000 tons per annum for three years, before exhausting the area. The peat forms a solid layer about 30 inches thick and is overlaid by about eight inches of soil. The top soil is removed by spades and the peat cut out in square blocks, which after several days' drying become quite hard and are ready for transport. About 80 workmen are employed at piece work rates, and earn an average weekly wage of \$44. After the removal of the peat the ground is useless for agriculture, as it is water-logged. If, however, a comprehensive system of land drainage were adopted, and the top soil spread over the surface again, the land should be restored to its former value.

Peat from some of the deposits does not coalesce when dried and this is treated by grinding with water. The resulting mud is drained on wooden frames, and after a few days' drying forms blocks which are not liable to crumble. Jutland peat is very low in ash, but contains a high percentage of moisture. The Government maximum price is \$10 per ton f. o. b. producer's works, on a basis of 40 per cent total ash and moisture, with an adjustment either way of 18 cents per ton for each per cent above or below this figure. The calorific values range from 3600 to 4500 calories. The industry is purely an emergency war-time measure, and can hardly be expected to survive competition with imported coal.

The peat area is said to be as much as 28,000 acres. According to "Ingenioren" this could be completely drained by gravitation, and the total contents might be equivalent to 23,000,000 tons of coal. It is suggested that the peat could be utilized: (1) as air-dried briquet used for heating the boilers of adjacent electrical supply works, (2) as machine-made briquets sold for general consumption as far away as the cost of transport will allow, (3) as peat litter to be sold to neighboring farmers, (4) the lower parts of the bog should be reclaimed and used for agriculture. The heating value of the peat is assumed to be half that of coal. The works required should be executed by private enterprise, aided by the State, and the cost of reclaiming would amount to \$250,000. The first 9000 acres could be dealt within 20 years, and the rest of the land occupied in course of time as the peat is cleared away.

PEAT BRIQUETS.

F. J. Diessenbach (Swiss Pat. 77,343, April 1, 1918.)

Peat briquets are formed of a compressed mixture of 70 parts lampblack, 30 parts comminuted peat or similar combustible material, 5 parts of an asphalt binder and 2 parts of lime dust.

PEAT BRIQUETS.

F. J. Diessenbach Swiss Pat. 77,343, April 1, 1918.)

Briquets are formed from a mixture composed of 30 percent finely pulverized peat, 30 per cent peat powder of one millimeter size grains, 20 percent sawdust, from large-leaved trees, 10 percent pitchy soot finely pulverized and 10 percent pitchy soot of one millimeter size grains.

PEAT DISTILLATION.

Bertzit Ges. (Ger. Pat. 306,956, March 21, 1916.)

The material is partially dried, to a moisture content of 10 to 20 percent, by a counter current of moderately moist air prepared by mixing the waste heating gases arising from the furnace with cold air. The peat is first dried to a moisture content of about 50 percent.

NON-HYGROSCOPIC PEAT FUEL.

Bertzit Ges. (Ger. Pat. 306,880, Dec. 6, 1913.)

The material is first dried at a moderate temperature and then heated with exclusion of air to between 180°C. and 250°C. until evolution of water, carbon dioxide, and nitrogenous gases is complete. Esters and imides contained in the material are thus decomposed and the bituminous portion of the fuel swells and fills up the pores, preventing the absorption of water.

DISTILLATION OF PEAT.

C. Turner (Br. Pat. 117,645, 1917.)

Destructive distillation of peat is carried out in a vessel which is alternately closed until the pressure therein has attained a desired maximum and then opened so that the pressure is reduced rapidly from this maximum solely by expansion. The heating may be external, or internal as by the circulation of a heated elastic fluid. As an example of the process, peat is treated to obtain a maximum yield of oil with superheated steam at a temperature of 500°C. in a jacketed iron cylinder, and the steam is admitted until the pressure in the cylinder is five pounds above atmospheric pressure. The pressure is then relieved by opening a cock which leads to the con-

densation plant for the oils, etc. The products of distillation include ammonia, methyl alcohol, acetone, acetic acid, pyridines, mono-phenols, guaiacol, cresol, and other phenols, a petrol-like spirit, other neutral oils, and parafin waxes.

PEAT FOR FUEL.

K. E. Edgeworth (Br. Pat. 118,903, Sept. 24, 1917.)

This invention relates to the manufacture of peat for fuel, and to that method wherein the peat is first heated to a temperature of 150 degs. Cent. or over in a closed vessel, thereby reducing it to such a condition that the greater part of the water can be eliminated in a filter press. Peat which has been subjected to such treatment will be referred to as "carbonized peat." An improved form of filtering apparatus is provided wherein a higher percentage of water can be abstracted from carbonized peat than is possible with the forms of apparatus now in use. The filtering elements, which are made of unglazed porcelain, or earthenware, are so arranged in the filter vessel that they are wholly surrounded by the substance to be filtered, whereby they are enabled to withstand the high pressures to which they are subjected, which is not the case when the pressure is applied from one side or from within. The filtering elements themselves may be in the form of plates, discs, cones or tubes. The filtration is carried out under considerable heat and pressure, and it is convenient to pump the peat directly into the filter from the vessel in which it is carbonized, thus saving both heat and power. When filtration is complete, and while the material still retains a portion of its heat and pressure, provision is made for suddenly releasing the pressure within the filtering vessel, whereby a sudden generation of steam takes place which disintegrates the mass and detaches it from the filtering material.

APPARATUS FOR TREATING PEAT.

C. Bouillon (Br. Pat. 118,993, Mar. 15, 1918.)

It is known that peat contains an admixture of vegetable fibres which possess properties having a great industrial and commercial value. On the other hand, their presence in the peat does not affect the properties of the peat, which are different from those of the fibre. The proportion of fibre mixed with the peat varies with the position occupied by the peat in the layer of peat. Usually, but not necessarily, the proportion of fibre is largest in the top layer of peat. This invention relates to a continuous process and to apparatus for isolating the fibres, grading them and reducing the remaining portion of the peat to a pure and anhydrous state. The process allows any quant-

ity of raw peat to be treated, the fibre and water being mechanically removed as well as the foreign matters to which the fibres adhere.

RAISING AND DRYING PEAT.

T. E. Doyle (Br. Pat. 120,850, Apr. 23, 1918.)

This invention relates to improvements in connection with the raising and drying of peat, and refers particularly to the carrying out of these operations with pieces of peat of considerable dimensions and of any suitable shape, such as prisms, columns, walls or the like, and to means whereby the soft peat, in whatever shape it may be cut out, is temporarily reinforced so as to bear the necessary handling, and be capable of being placed in an upright position as it is raised out of the bog. The object is to reduce the loss of time and labor involved by the repeated handling of peat in the customary small pieces or sods, and which are necessarily laid flat on the ground as they are dug out, and require handling and attention at intervals during the process of drying. In the case of machinery operated by mechanical power, and which would be heavy and liable to sink into the bog, the material employed to reinforce the peat would be stouter, and would be utilized to serve the purpose of "piles" for the time being, to provide a foundation for the heavy machinery, and would be driven down into the peat in front of the machinery as it advances across the bog. In the case of hand-operated machine which would not be heavy or liable to sink, the reinforcing material may be driven into the peat either at the front or back of the machine.

PEAT FUEL.

L. le Warner Hamon (Br. Pat. 121,102, Aug. 20, 1918.)

According to this invention, the materials or ingredients employed comprises one or more raw carbonaceous substances of the kind specified hereinafter, together with tar, pitch or similar combustible distillation products or residues, and in addition cellulose, silica, and preferably a small percentage of alkali. These materials are manufactured into a bituminous artificial coal which is capable of being converted into smokeless fuel if required. The artificial coal is made, for example, in three grades from variable mixture of the following materials ground into powder and freed from moisture to about 30 percent by any known system of air-drying or mechanical means, viz., lignite, peat, sud, leaf mould, or shale, in combination with cellulose, such as sawdust or fibrous vegetable matter of a cellulose nature, and silica, together with tar or pitch or residues from tar or pitch or residues from oil distilla-

tion, with a percentage of any of the known alkalies, such combinations being mixed together in proportions as hereinafter described and pressed into blocks by any form of briquetting machinery known and in general use. The percentages of any of the above materials depend on the countries where these materials are more easily obtained, and where the aforesaid artificial coal or fuel is proposed to be manufactured, and are as follows:

GRADE I.

	Percent	
Lignite, Peat, sud, leaf mould or shale, dependent on the quality or texture of any one of these materials	50	to 60
Cellulose	15	to 20
Silica	12½	to 15
Pitch or tar residues of same or residues of oils.....	20	to 25
Alkali	2½	to 5

GRADE II.

Lignite, peat, sud, leaf mould or shale.....	50	to 60
Cellulose	10	to 15
Graphite, carbon, anthracite or coal dust, coke breeze, slag, cinders or culm.....	15	to 20
Silica	4	to 8
Alkali	1	to 2½
Tar or pitch, residues of same or of oils.....	20	to 25

GRADE III.

Lignite, peat, sud, leaf mould or shale.....	50	to 60
Cellulose	10	to 15
Graphite, carbon, anthracite or coal dust, coke breeze, slag, cinders or culm.....	15	to 20
Silica	1	to 5
Alkali	1	to 2½
Clay, ironstone, black band, iron sands, manganese ores or oxide of iron.....	1	to 2
Tar or pitch, residues of same or of oils.....	20	to 25

To obtain the smokeless fuel hereinbefore referred to, the above blocks as made by any of the above formulas are passed into any retort or retorting chamber of known use, and after subjecting the said blocks to the usual temperature employed in coking coal in general use, the result is a smokeless fuel to be used for all purposes for which coke is at present employed.

ARTIFICIAL FUEL WITH PEAT.

T. Twynam (Br. Pat. 121,373, Dec. 31, 1917.)

This invention relates to the production of artificial fuel from mixtures of pitch with coke breeze or gas coke, small or duff coal, or other forms of carbonaceous material unsuitable for use as fuel, owing to their physical condition and lack of volatile matter, with peat, thus utilizing the peat so as to render it useful for fuel purposes in ordinary domestic grate, gas producers, boiler firing, etc. The invention also makes use of pitch so as to render it available for use as a fuel for ordinary household purposes and for use in gas producers and other manufacturing purposes, for which its low softening point at present renders it unsuitable except when used in very small quantities as a binding material. The drawbacks attending the use of peat alone as a fuel are very well known, as it smoulders away with practically no flame, and is consequently not at all well adapted for use in the ordinary domestic grate or for industrial purposes. Peat also, when freshly dug from a peat bog, contains some 80 to 90 per cent of water, which is only partially given off by air drying. It is also found impossible to squeeze out the water by pressure alone. To produce the artificial fuel it is proposed to take any form of small coke, such as that screened off from metallurgical coke, or coke breeze itself, and grind it up with dry pitch in any suitable machine, so as to incorporate the two bodies well together, and when sufficiently ground to introduce them into a pug mill or other suitable mixing apparatus in which the wet or only partially dried peat has been already placed, and then incorporate the whole together by suitable grinding. The proportions found to give good results, when using wet peat as dug, are per 100 parts of wet peat 15 parts of the coke dust and pitch mixture, but these proportions may be varied within fairly wide limits. When the coke dust and pitch are mixed together in the proportion of three to two, the volatile matter in the fully dried product will be found to be very similar to that in good household coal. The resulting mass, after the mixture of coke dust and pitch has been well incorporated with the peat, can be moulded into briquettes or blocks by mechanical pressure if desired, but for ordinary domestic use it is generally sufficient to flatten the mixture down slightly to convenient thickness for drying, and after drying to cut it roughly into pieces of the required shape. After drying, the material is ready for use as a fuel. It is preferable to dry the material by waste steam, placing the mixture on iron plates under which the steam circulates; at the temperature thus obtained the ma-

terial dries readily. The gritty coke dust tends to split up the cell formation of the peat, and thus allows of the more ready removal of the contained water. When the resulting dried product is gasified in coke ovens, the ammonia and gas from the peat and the gas from the pitch can be utilized in the usual manner. The gas is of a high calorific value, and can be used for illuminating, or power, or for metallurgical purposes. The coke remaining after the gas has been driven off also forms a fuel suitable for household or other purposes, as the peat carbon it contains readily ignites. In place of coke dust any form of coal dust or small coal may be employed, or this may be used in addition to the coke dust. It is an essential part of the invention to grind the wet or only partly dried peat by mechanical means intimately with the coke dust, small coal or hard pitch, so as to break up the cell formation of the peat and allow the rapid escape of the water by subsequent drying.

PULVERIZED FUEL.

N. K. H. Ekelund (Br. Pa. 122,214, Nov. 17, 1917.)

Pulverized charcoal or coal is found to be difficult to use as fuel. Both of them are hygroscopic, and, owing to their consistency as powder, absorb still more water out of air than charcoal or coal in a solid form, whereby risk of spontaneous ignition arises. Such powder during transport and storage readily cakes in lumps, when it is difficult to feed it forward in the furnaces or hearths intended for burning pulverized fuels. By the absorption of water the caloric value is diminished and the powder becomes difficult to light and burn. The present invention is intended to produce from pulverized charcoal or coal a powdered fuel without the drawbacks above referred to, and the novelty of the invention consists in the fact that finely ground and thoroughly dried charcoal or coal is mixed with a finely divided and thoroughly dried powder or peat, the peat powder having been exposed, before the close grinding, to an artificial drying at a high temperature; for example, at 100 degs. Celsius. By drying the peat powder at a high temperature the peat particles lose their structure, whereby the peat powder becomes unhygroscopic and prevents the pulverized charcoal or peat from absorbing moisture from the air. As the peat powder is elastic, it prevents caking and packing into lumps, wherefore it easily allows itself to be used as pulverized fuel in furnaces or hearths. Finally, inasmuch as the peat powder is easily ignited and easily burnt, it forms in the furnaces or hearth chamber a flame by which the pulverized charcoal or coal is ignited and burnt. The proportions of pulverized charcoal or coal and peat powder depend upon the

various conditions of the coal and peat, and will vary according to such condition. The smallest quantity of peat in any case will, however, be 10 per cent by weight.

PEAT FERTILIZER.

J. R. Robinson (Br. Pat. 116,758, June 20, 1919.)

Manures are obtained by treating with yeast, under conditions to encourage growth, peat, peat moss, soil and cellulosic or soil-like materials such as rape meal, castor meal, seed husks or refuse, sweepings from maltings, residues from beet sugar refineries, decayed vegetable matters, sludge from cesspools, road sweepings, destructor residues, etc. The materials are ground or finely divided, mixed with a lime compound such as lime limestone or dolomite, and treated with yeast at temperatures of 70 to 100° F. Phosphatic materials such as steamed bone flour, basic slag, ground coprolites or ground mineral phosphates, potash compounds such as chloride or sulphate, kainite or flue dust, sodium chloride or magnesium sulphate may be added before the treatment with yeast.

FERTILIZER FROM PEAT.

N. Testrup and T. Rigby (U. S. Pat. 1,277,155, Aug. 27, 1918.)

A fertilizer is prepared by heating peat to 100 to 180°C. under pressure to destroy its water binding properties, reducing the water content to not more than 68 percent, gasifying part of the product and treating the other part with ammonia evolved in the gasification.

NITRATES BY BACTERIAL ACTION.

C. T. Thorssell and H. L. R. Lunden (U. S. Pat. 1,288,756, Dec. 24, 1918.)

A porous solid substratum material such as peat or sponge carrying nitrifying bacteria is mixed with limestone and perforated trays containing this material are placed one above the other. A solution of ammonia salts to be oxidized is allowed to percolate through the materials in the trays while exposed to free access of air.

DYES FROM PEAT.

A. M. Hart (Br. Pat. 120,588, Aug. 13, 1917.)

Dried and powdered peat is treated with sulphuric and nitric acids, either in succession, or together, and the solution filtered. The "acid filtrate" so obtained, diluted with water, may be used alone as a dye bath, or may be diazotized with sodium nitrite, and used in conjunction with a grounding bath of beta-naphthol or a metallic mordant as potassium ferrocyanide.

anide, and if desired, a developing bath of naphthylamine. Alternatively the acid filtrate may be neutralized with sodium carbonate, or the like, and allowed to crystalize, a solution of the crystals being used as before. The bath may be used also for treating cotton previous to dyeing with colors which are not readily applied to that fiber, for instance cochineal.

An Electric Bell For Opportunity

Don't make Opportunity knock.

Have a loud ringing electric bell ready
to warn of her slightest touch at your
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In the shape of savings—War Savings
Stamps—money in Bank.

Ready to take you whither she beckons.

Debts deafen one's ears to Opportunity
—ready cash is her favorite telephone.

Begin to save—to-day—for the Sunny
Opportunity she offers every one—*once*.



Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York, City.

Dear Sir:—

I, the undersigned, being interested in the development
of our peat resources and in the welfare of the peat Society,
beg to make application to membership in your Society, for
which I enclose \$5.00 as annual dues.

Signed

Address

.....

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NOTE.

The publication of articles in the Journal of the American Peat Society is not an endorsement of the same by the Society or its officers. The American Peat Society is not responsible for the statements and opinions advanced by authors or correspondents. Written discussions on articles appearing in the Journal are invited. Correspondence and articles regarding peat and cognate subjects solicited.

PEAT AND ITS AGRICULTURAL APPLICATION.

Peat has to ward off many knocks, has done so in the past and can endure many in the future. The advances in the study and economic utilization of peat, during the last two decades, have brought peat into being recognized as one of our natural resources. As we have often explained in these pages peat failures are in a great measure due to plausible and removable causes, nevertheless experiments with peat in various directions are liable to give disappointing results. An experiment can never be a failure, provided the available knowledge is made use of; its results may not prove commercially economic, but we cannot speak of an experiment being a failure, as its results, whether favorable or otherwise, must be a valuable addition to our existing knowledge of peat.

When a chemist, yea, a professor of agricultural chemistry, namely Prof. John S. Burd of the University of California, issues a circular on "Peat as a manure substitute," which we published in our last issue on page 53, wherein he first advocates the virtues of organic material as unquestioned and then condemns peat in comparison with animal manure, we are bound to feel perturbed.

What hurts us most is not so much the misleading and superficial statements he makes but the absolute ignoring of what has been done on this subject. If Prof. Burd had taken the trouble to ascertain the status of the use of peat as a fertilizer, he would never have published his circular. Even in his own State peat has given satisfactory results, where it has been intelligently prepared for the soil.

For the benefit of Prof. Burd let us state here that not every peat can be used for a fertilizer ingredient nor as a soil amendment; further the peat which can be used in the soil must be properly prepared to be of any value. That peat has been wrongly prepared and applied in California can be seen from the statement made by Dr. W. P. Kelly who states that "lumps of peat can still be seen in the soil," leaving no doubt regarding the faulty preparation and application of the peat; yet the most astonishing thing is that, the California Department of Agriculture cognizant of the condition of the peat used, have lacked the proper knowledge regarding the agricultural application of peat to the soil, otherwise they would have recognized that the peat applied has not been properly prepared to obtain favorable results. In fact improperly or unprepared peat added to certain soils can do more harm than good.

The virtues of dried peat properly composted and treated make a splendid manure, we have so often alluded to the excellent points of peat; that were corroborated on numerous practical applications to the soil, that it is not necessary here to discuss Prof. Burd's assertion of the ill effects of dried peat. If Prof. Burd wanted to make the utilization of peat economic to the agriculturists of his State, he would write a circular on "How to make peat a manure substitute," but he would have to avail himself of existing knowledge on this subject to give them intelligent advice; and he would have to elucidate clearly the advantages of properly prepared peat over animal manure, and also how its disadvantages over animal manure can be overcome.

On another page in this issue we publish an article entitled "Inoculation of Soils" by Robert Ranson, which saves us from discussing Prof. Burd's or rather Dr. Chas. B. Lipman's paragraphs on "Inoculated Peat."

Herbert Philipp.

WILLMARTH PEAT FUEL PROCESS.

By C. A. Willmarth.

As you have requested me to write an article for your Journal, I wish to say, so much has been written about Peat in a general way, and so much of it of little value to the people who would like to manufacture it into fuel, that I will state my experience for the past five or six years in as few words as possible. After having had considerable experience in briquetting other material, I turned my attention to peat. First, I procured all the books and literature I could from the Government and Public Library and put to practical test such suggestions and processes as looked practical, only to find that none of them had or could be made to produce the desired results; so I undertook with plenty of capital behind me (which I found very handy) to find out what the trouble really was, and all of you who have had experience, know the cause without me mentioning any of the innumerable failures. I will state the one most essential: they could not extract the water cheap enough, nor make a high-grade fuel entirely out of Peat, and I am inclined to think the reason was most of them did more talking and suggesting than practical work; or in other words, they found the other fellow's money came so easy that they were more interested in getting some of it than they were in working out a process; but don't understand that to

accomplish the desired results, was an easy task; it was over four years before I could say I had finished experimenting, and I worked at Peat all the time. The process of making Peat coke or charcoal, and gas is so simple with the proper machinery that any intelligent man can operate it without trouble, and making fuel is just as easy; keep the disintegrator filled with raw Peat and it will devour about ten tons per hour, and you will then have three tons per hour of air-dried fuel.

Because all reports say that Peat contains about 90% moisture, most people think this has to be removed to make fuel, not so, when 70% is removed you have an air-dried fuel and any further drying is of no benefit, and only 40% should be removed artificially; the rest should be allowed to evaporate in the open air, or in dry sheds, to make a high-grade fuel.

Our government has urged the engineers of this country to profit by machines already in use in the old country, and improve and adapt them for use in this country, but they do not mention the machines that have been patented in this country, and I will say that in 1866 there was a machine patented which I believe is equal to any now made in foreign countries, and had the demand for Peat fuel been as great then as it is today, his machine would have been so improved that probably my patents would never have been granted.

When the United States entered the war we asked to be put into the priority class for material. We were referred to Dr. Garfield, only to find he was very much opposed to assist in putting (as he called it) a low-grade fuel on the market at that time to encumber our already overburdened railroads. So we sent him samples of our fuel that he might test them and also explained to him that we were making a high-grade fuel. In any event we were making fuel where there was no coal fields, and where large quantities of coal would have to be shipped, therefore we were relieving the railroads of one of the greatest items of railroad traffic, nevertheless we got an answer saying he absolutely would refuse to assist us.

However, we have received great assistance from other Government officials for which we are very thankful.

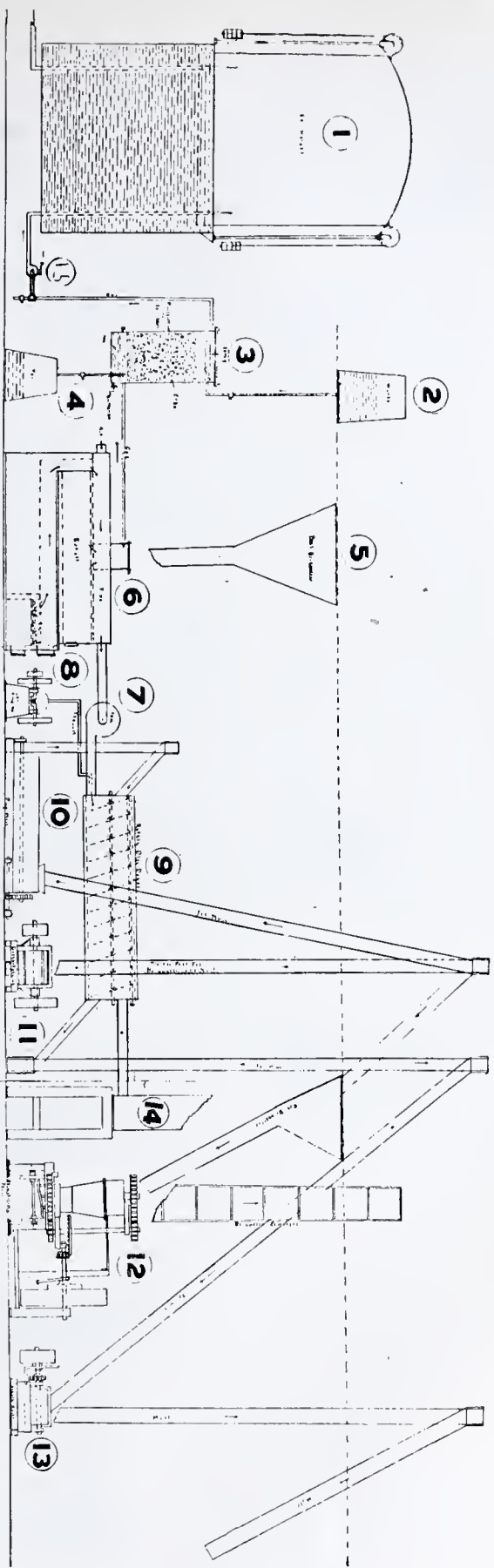
Process of Willmarth Gas, Coke and Fuel Plant.

The retort is first filled with air-dried peat, and fire started, in the usual way. Then, as the raw peat is taken from the bog, it is first run through a disintegrator—a heavy machine that has two rolls twelve by twenty-two inches with tool steel cutting bars extending from the rolls and running at differential speeds of 100 and 900 revolutions per minute respectively, thereby rolling and cutting up the peat and all

foreign substances. Then it is elevated to a hopper over the pug mill which cuts and grinds the peat into a loose granular form. Then it is sent to the dryer, designed especially for this purpose, being a drum three feet in diameter and twelve feet long, having parallel strips on the inside three inches high and one foot apart running the entire length. As the drum revolves the peat is carried upward and dumped upon adjustable slotted discs, and at the same time the waste heat is drawn from the retort, also the exhaust from the gas engine, and forced with a fan through the drum and discs to the smoke stack. This leaves the peat in an air-dried condition and it is then elevated to the floor and hopper above the retort which is designed especially for our process, having a flat cast iron bottom three-quarters of an inch thick, three feet wide and twelve feet long, covered with a wrought-steel shell having straight side walls two feet high, and a dividing sheet of steel two feet from the bottom, which forms the retort proper; then the side walls extended in oval form one foot high, which is the return flue, allowing the retort to be heated on the top as well as the bottom. The retort is enclosed in a brick wall, the same as a boiler. After the retort is filled and fire started the gas and tar are rapidly removed and pass through a purifier and scrubber, which is an upright tank partly filled with coke and a spray for continually wetting same which removes the tar from the gas, the gas being drawn and forced to the gas holder by a centrifugal pump. The retort holds 72 cubic feet, or 1,440 pounds of air-dried peat. This will make 8,500 cubic feet of gas, 10½ gallons of tar and 650 pounds of coke, or 800 pounds of half coke, which makes the best fuel for boilers and domestic purposes. The gas is used for power purposes, heating the retorts, building, etc. The coke, which is about half the weight of peat used, is cooled and then elevated to the hopper over the mixer, where peat that has been disintegrated is also placed. After being thoroughly mixed and ground in the pug mill, it is sent to the smooth roll grinder, which is a heavy machine having two adjustable rolls 12 inches by 22 inches running at differential speed so that the coke is ground with the peat, breaking the minute cells holding the water. Then it is sent to the hopper over the auger press or open die press where a portion of the water is removed by our specially made strainer dies, which leaves the briquettes in a condition that they will quickly air dry in sheds, to which they are removed on a belt conveyor, or a chain conveyor may be used with iron frame and hood with gas heaters underneath so that the briquettes will be dry enough to go direct to the storage bins.

When peat is to be used in making fuel without coking plant the crude peat as taken from the bog is first delivered to the disintegrator, whose action is to destroy its natural organization and tubular character of the undecomposed fibers which are interlaced through it, then it is sent to the mixer, which is located on the head end of the pug mill, where it is mixed in the proper proportion with breeze (coke dust) (the breeze can be procured from any gas-producing plant). This mixture then drops into the pug mill, where it is ground into a plastic mass; it is then sent to the smooth differential rolls, where the grit of the breeze breaks the minute cells that hold the water. As this plastic mixture leaves the rolls it is greatly condensed and diminished in bulk, even before it goes to the press, it is found to have great density in comparison with its condition when crude, and then it is sent to the press where it is properly formed, and the desired portion of the water is eliminated, the balance is required to make a high-grade fuel when drying.

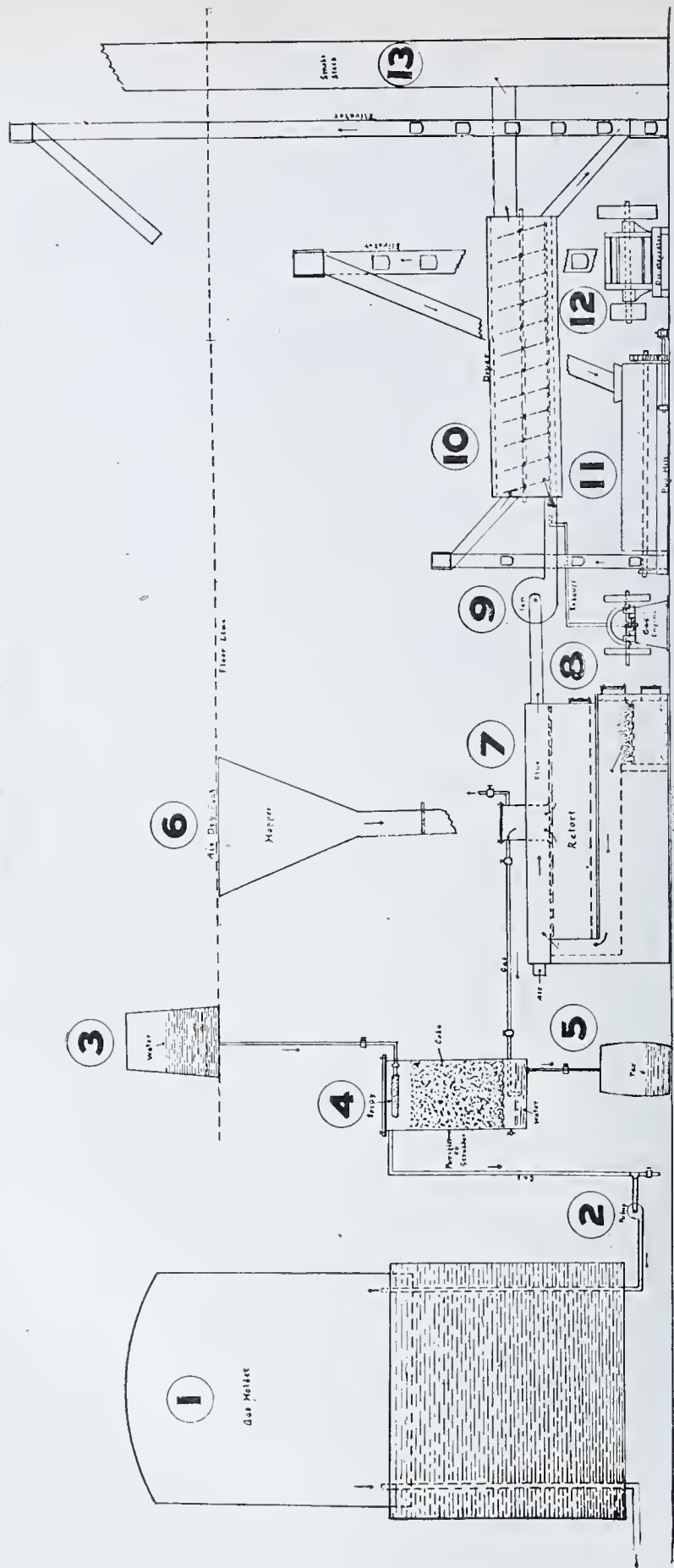
COMBINATION PLANT FOR MAKING COKE BRIQUETS AND MULL OR FERTILIZER FILLER.



- 1—Gas Holder
- 2—Water Tank
- 3—Purifier and Scrubber
- 4—Tar Tank
- 5—Hopper above Retort
- 6—Retort
- 7—Blower Fan
- 8—Gas Engine
- 9—Rotary Dryer
- 10—Pug Mill
- 11—Disintegrator
- 12—Briquetting Machine
- 13—Centrifugal Pump
- 14—Smooth Rolls
- 15—Smokestack

The above cut is an outline of the machinery used in our combination plant. The products of this plant are coke or charcoal briquets, mull or fertilizer filler, gas and tar. The by-products from the tar will nearly, if not entirely, pay the running expenses of the plant. The Peat may be one-half coked and used for fuel purposes, or thoroughly coked for smelting purposes. The retorts will produce about 1,000 pounds of one-half coke or 850 pounds of coke per hour; at the same time producing about 9,000 cubic feet of gas. The gas produced is ample for power purposes, running the retorts, heating the plant, etc. This unit will also produce about one ton of mull per hour. The waste heat from the retorts and gas engine is used in the rotary disc dryer for making the mull.

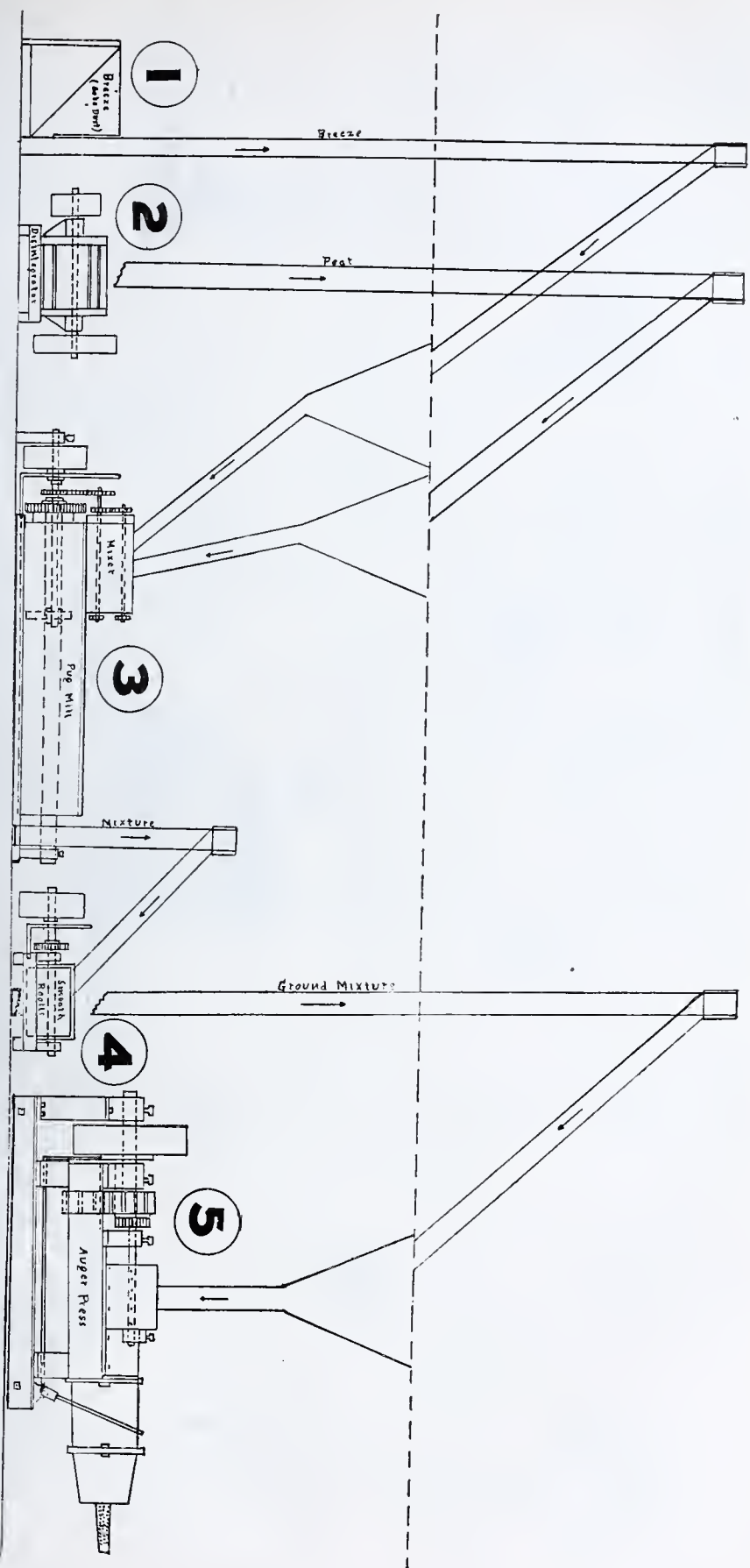
GAS AND COKING PLANT



- 1—Gas Holder
- 2—Centrifugal Pump
- 3—Water Tank
- 4—Purifier and Scrubber
- 5—Tar Tank
- 6—Hopper above Retort
- 7—Retort
- 8—Gas Engine
- 9—Blower Fan
- 10—Rotary Dryer
- 11—Pug Mill
- 12—Disintegrator
- 13—Smokestack

This plant is designed especially for making gas, tar and coke dust (breeze). Peat contains from 10,000 to 12,000 cubic feet of gas per ton and 800 or 900 pounds of coke. With two retorts, each holding 1600 pounds of air-dried Peat, one can be coked while the other is emptied and refilled, making the process continuous; and the output approximately 9,000 cubic feet of gas and 700 pounds of coke per hour. If a fuel plant is not desired, a briquetting machine should be used so the coke or half coke, whichever it is desired to make, could be used either for fuel or smelting purposes.

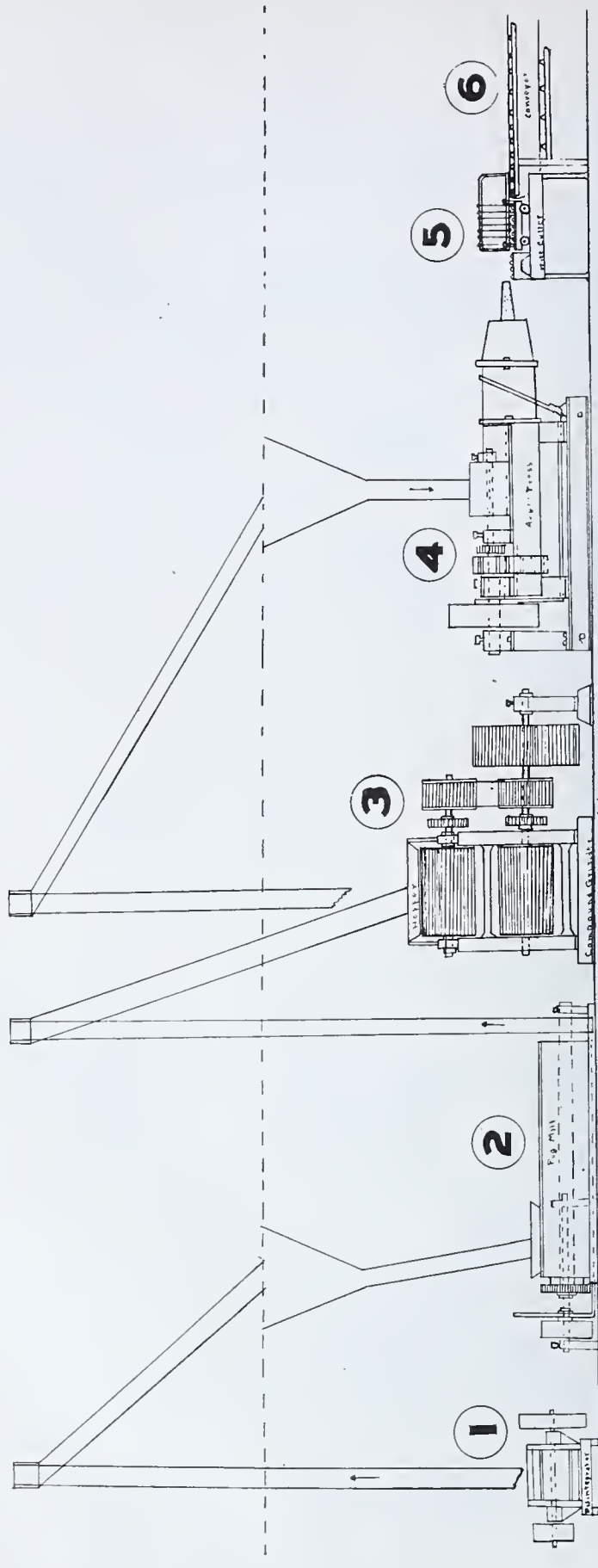
MACHINED FUEL PLANT



1—Breeze (Coke Dust) Hopper; 2—Disintegrator; 3—Pug Mill; 4—Smooth Rolls; 5—Auger Press.

This is the first process invented for breaking the water cells and producing a high grade fuel from Peat. It is designed and adapted to be used in connection with the Peat Coking plant where breeze (coke dust) is used to assist the machinery in breaking the water cells to produce high grade fuel.

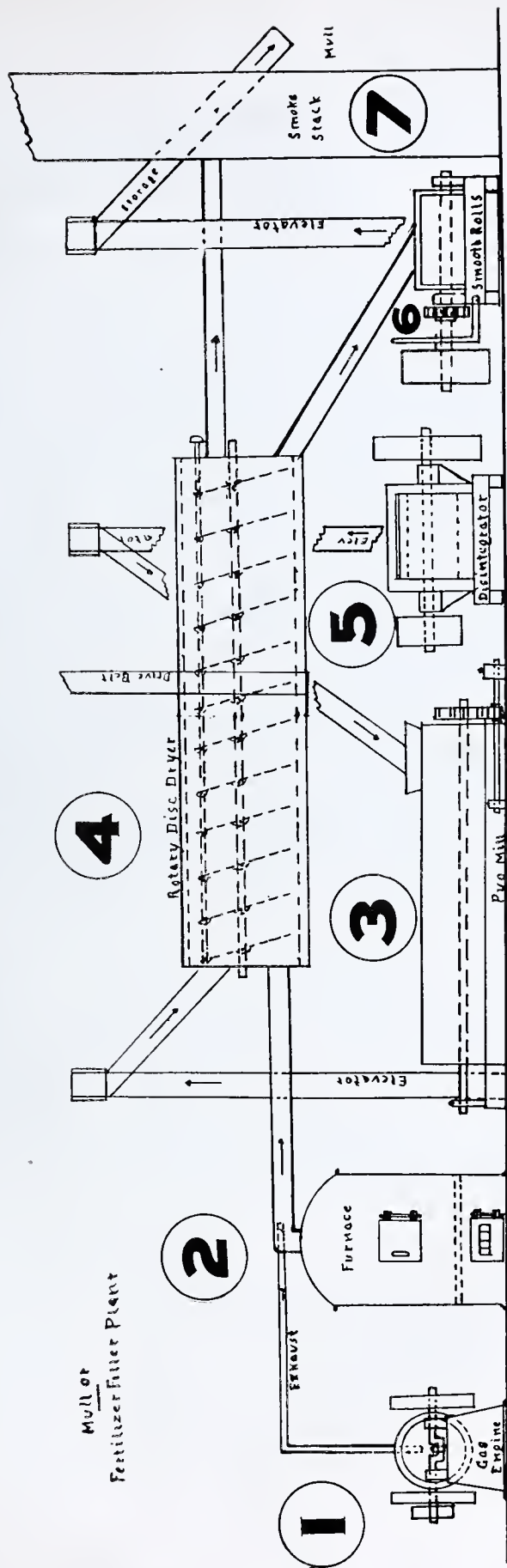
SPECIAL MACHINED PROCESS FUEL PLANT



1—Disintegrator, 2—Pug Mill, 3—Compound Grinder, 4—Auger Press, 5—Wire Cutter, 6—Conveyor.

This is a later process for breaking the water cells in Peat, when a coking plant is not used. The fuel is water-proof even when submerged. This fuel has also been thoroughly tested and proves to have the same high heating qualities as the other fuel. This plant may be installed in a room 24 feet by 36 feet. One is now being installed at Cheisea, Mich.

MULL OR FERTILIZER FILLER PLANT



1—Gas Engine, 2—Furnace, 3—Pug Mill, 4—Rotary Disc Dryer, 5—Disintegrator, 6—Smooth Rolls, 7—Smokestack.

I wish to say a few words relative to the preceding processes and the results and benefits of breaking the water cells in Peat before they are allowed to dry. With the coarse machinery used in the old country, where about 20,000,000 tons are made annually, very few, if any, of the cells are broken; therefore it takes a long time for the fuel to dry, and as it dries to a certain extent before the water cells begin to shrink, when they are shrunk they leave innumerable small cavities. or in other words the fuel is honey-combed when dry, which makes the fuel light and bulky. Whereby if the cells had been broken while the Peat was yet in its plastic form, it would have broken into a solid mass, and have only been about one-half as bulky. Then we have a high grade instead of a low grade fuel from the same material. To accomplish this in a commercial way has been my aim for years and I have improved and patented several processes, until now I am able to put before the public a process that will make Peat into a fuel far superior to coal, both in heat units and cleanliness. Otherwise if nature had been allowed to destroy the cells through years of decay it would have been transformed into coal containing large quantities of soot, ash and smoke. Therefore I confine myself to the practicability of breaking the cells and so treating the Peat that it would be aged thousands of years before nature would transform it into bituminous coal. In doing this, owing to the large amount of water contained in Peat, it was necessary to build large machines that would have capacity enough even where fine work was required, to make it a commercial success, and as the substance is so changed I could hardly call it Peat, so I have termed it "Process Fuel."

INOCULATION OF SOILS.

By Robert Ranson, St. Augustine, Fla.

The recent publication by the State Chemist of Florida, Capt. R. E. Rose, of a leaflet condemning a preparation widely advertised and sold in Florida and elsewhere called Phos-Pho-Germ, manufactured in Ocala, Fla., under a license from the parent company, the American Nitro-Phospho Corporation of Richmond, Va., is of great interest to our growers, for the reason that the discussions emanating therefrom brings to our notice the ever increasing interest in such matters as to what may, or may not, be expected in results from the inoculation of our soils with various bacteria.

Unfortunately up to date, the State of Florida has not awakened to the necessity of establishing a bacteriological laboratory, therefore it was only possible for our State chemist to estimate the worth or otherwise of this particular material from a standpoint of value, based on the present unit cost of the three principal fertilizing elements, recognized by the trade as necessary ingredients of all fertilizers, Ammonia, Phosphoric Acid and Potash.

This was done, with the result that Phos-Pho-Germ showed an actual plant food value, leaving out expense of mixing, sacking, etc., of about seven or eight dollars a ton, and as it was sold at from forty to forty-five dollars, it was, of course, deeply interesting to learn what was offered for the thirty-five dollar deficit.

Although, as far as can be learned, this material was not offered for sale in Georgia. The Commissioner of Agriculture of that State was moved to examine into this matter and in turn passed it on to Dr. W. C. Dumas, his State Chemist, who then had it examined by the State bacteriologist, and in all, five men of unquestioned standing in their respective lines of work, examined and reported on this material as a fertilizer.* Their efforts show a spirit of fairness and tendency to protect the farmers and, taken as a whole, their findings will stand for a long time, if not always, as a classic on the subject of soil inoculation, as it is known up to date.

This is published in full in the April issue of the Journal of the American Peat Society, together with a reply from the Richmond headquarters of the Phos-Pho-Germ Company, accompanied by a letter from Dr. G. H. Earp Thomas, the inventor and patentee. I have since taken the opportunity to

*See this Journal 1919, Vol. XII., p. 75.

communicate with all the parties concerned and feel competent to add considerable light to this discussion and bring out some new points.

The report of the Georgia State Chemist shows the chemical analysis of Phos-Pho-Germ under twenty-four heads the exact proportions of which are listed, from which some idea of the pains taken may be estimated, and no objection is taken to its findings by Dr. Thomas. He claims, however, that the bacteriological report is incomplete and harmful.

In his reply the doctor states that Phos-Pho-Germ contains sixty-five varieties of bugs, domestic and foreign, and over twenty billions of living bacteria to the gram, which, working harmoniously together, make soluble the mineral and organic compounds, principally ground peat and raw phosphate; to such advantage, that so considered the price is a fair one.

The real bone of contention, from a bacteriological aspect between the State bacteriologist of Georgia and Dr. Thomas, is that the former claims that so far only symbiotic bacteria have proven of any real value; that is those which work and grow only in close connection with the roots of leguminous plants, whilst the latter claims vast advantages by using free growing azotobacters in the soil. Azote is the Greek word for nitrogen, the azotobacter is a class of bugs whose business it is to gather up all the loose nitrogen lying round and store it up in the soil for the later use of plants, something in the way a bee stores up honey, only as the bugs in question are so minute that they could sit, fifty thousand strong on the end of the honey bee's sting without causing him the slightest inconvenience; the comparison is perhaps scarcely fair.

As I see it, the greatest advance in this branch of study, since the notable discovery in 1877, by Schlossing and Muntz, of nitro-fixing organisms in the nodules on the roots of legumes, is that, usually credited to Professor Bottomley, of King's College, London, England, that peat or semi-decayed vegetable matter was unexcelled as a habitat for nitrifying bacteria.

The explanation of the suitability of peat as a medium for nitro-bacterine is that its mechanical structure renders it unexcelled as a bug's home, and further, that it furnishes just the right kind of food for their continued activities in adding nitrogen to the soil. Either as a sequence, or by right of prior discovery, Dr. Thomas uses peat also in Phos-Pho-Germ, but as this must, to be of value for such purposes, contain just the right amount of moisture and be in perfect condition to pre-

serve, feed and increase the bugs put in it, it can easily be seen that when not so conditioned, great havoc can be wrought in these populous colonies in a very short space of time. An excess or lack of moisture, acidity of soil, over nitrification and strong sunlight are well known to be fatal to germs of this character, to say nothing of conditions which may also be fatal to their life, of which we know nothing heretofore.

For their continued growth and activities soils must either be naturally rich in humus or organic matter or artificially brought to that point, and I consider Professor Clark's point along this line extremely well taken, that while the humus contained in the Phos-Pho-Germ may be and probably is sufficient to insure continued activity of the bugs, that when spread in soils lacking humus at the rate of one ton to each acre, which is in about the proportion of one thousand to one, there is every reasonable expectation that a very large proportion of the sixty-five varieties of bugs would perish and not increase at all, and very probably die out altogether.

The experiments with various soil bacteria carried out during 1912 to 1915 by Professor Bottomley and his assistants in Kew Gardens, London, England, on over forty-six different varieties of plants (non-legumes) showed a most extraordinary growth, and evidently from azotobacter free growing in the soil. It was further most conclusively proven from the even and well-balanced leaves, roots, branches and general growth of plants in soils high in ammoniates and very low in soluble phosphoric acid and potash, that bacterial action was responsible for making available to a marked degree very minute proportions of the two latter elements and balanced the inequalities of the soils in which the plants were grown. It was further established that bacterial action was responsible for the bringing into existence of a new plant food (still unnamed), but which was isolated in the laboratory by a noted agricultural chemist, which, when mixed in water in the proportion of sixteen parts to a million and then used to water plants once a week for six weeks, gave fifty per cent better results than on the best greenhouse soils untreated.

In 1916 I imported from England small quantities of Bottomley's Humogen (bacterized peat) and had very wonderful results with it in the Mill's Greenhouses in Jacksonville, illustrations of which appeared in the Florida Grower, accompanied by an article thereon on January 17th, 1917.

During the year following Bottomley's experiments in Kew Gardens a test on a large scale was inaugurated on the Rothamstead Proving Grounds, which is the equivalent of our agricul-

tural experiment grounds, in England.‡ Never was there a more complete fall down and it was published far and wide the world over, to the great detriment of the whole science of soil inoculation. The difficulties of correspondence and accompanying censorship of letters during the war prevented me for a long time from discovering what was the trouble, but after strenuous efforts I received an account of the failure and its causes from Mr. Robert Holmes, of Tuckswood Farms, Norwich, England, who, like myself, had been an ardent experimenter with Bottomley's and other soil inoculants, and I read a paper before the American Peat Society in Washington on the subject the following November. The reasons for failure briefly stated were that the preparation of humogen had been entrusted to incompetent and unscientific men.

The material was worse than useless and steps were immediately taken to prevent a repetition of such failures.

As long as Phos-Pho-Germ was prepared by Dr. Thomas who personally prepared his product, the successes were little short of remarkable, but the company who acquired the rights from him to manufacture under license, repeated the mistakes made in England, and in many cases Phos-Pho-Germ was a great failure in Florida this year. Almost all made and put out during January proved a failure. In certain places along the East Coast, however, most gratifying results have been obtained by its use and given testimony to a greater bacterial value than would appear from the statements of the Georgia authorities. I have become a firm believer as the result of observation and experiment, in the fact that without suitable bacterial action no fertilizer can be of any service to our soils and that all commercial fertilizers should be selected fully as much from the standpoint of their solubility and availability by bacterial action as from their value chemically considered. It is further evident that as we advance in our studies of the germ theory it will mean as much to agriculture as it does to medicine, and that as in medicine and surgery it has simply revolutionized both the old theories and practises in those sciences, so it will before long in agriculture.

There is little doubt but that the day is fast approaching when a correct symbiotic bacteria will be found for every kind of plant and many non-symbiotic ones of vast use in nitrifying and otherwise conditioning the soils; but that day has not yet arrived, and when men make such claims they must make them with their cards face up on the table and guarantee results or they will soon lose their standing.

‡See this Journal 1917, Vol. X, p. 126.

I commend my readers to give this matter close attention, otherwise many remarkable phenomena in grove and garden will be utterly beyond their comprehension.

Our soils, if not teeming with life, are nothing, but our task is to determine if that teeming life is beneficial or harmful to our plants. If beneficial, encourage it! if harmful, disinfect and sterilize your soils as soon as possible.

In all experiments go slow, especially with inoculants of unknown virtues. Recognize no esoteric teachings on the subject, only ex-oteric. Properly studied and practised all real students of the soil today can conceive of no higher benefits to mankind than correct conceptions of Soil Inoculation.

It is interesting and encouraging to note how many of our county demonstration agents and State and United States agricultural authorities are encouraging the study of soil inoculation when for several years the whole body of these men, except in rare instances, either ridiculed or ignored what individuals were trying to accomplish on these lines. In closing I desire to mention specially one of the failures of Phos-Pho-Germ this season in Florida, that at Hastings, Florida. An unscrupulous selling agent appeared in that section and induced by smooth talk several people to buy it for potatoes to the absolute exclusion of all other fertilizer, with the natural result that in a sour wet soil, somewhat lacking in humus, a most woeful failure resulted.

Not only was it extremely hazardous to use this material at all for Irish potatoes, but had the selling agent possessed the least knowledge of the soil requirements of nitrifying bacteria, combined with a slight sprinkling of honesty, he would never have taken the risk of selling this material for any such purpose. Professor Bottomley in England, Dr. Thomas in this country and many others I could mention have invariably guaranteed the results of their material and when for some unexplained cause it failed, have refunded the money paid, and in many cases I know of, have paid the farmer damages besides. In this manner alone can any confidence be built up? As Professor Clark says: "The sellers of these materials have cleverly taken extracts from scientific studies and letters from scientific bureaus, and used them in such a manner as to make it appear as if their own particular mixtures were officially approved."

NITRATES, NITRIFICATION, AND BACTERIAL CONTENTS OF FIVE TYPICAL ACID SOILS AS AFFECTED BY LIME, FERTILIZER, CROPS, AND MOISTURE.*

By H. A. Noyes, Research Associate in Horticultural Chemistry and Bacteriology, and S. D. Conner, Associate Chemist in Soils and Crops, Purdue University Agricultural Experiment Station.

Introduction.

The decay of organic matter and the transformation of nitrogen from one chemical combination to another were known and studied long before bacteria were isolated. These phenomena were attributed to purely chemical agencies until the discovery of the function of soil bacteria proved them to be almost entirely due to micro-organic life. Most investigations in soil bacteriology have dealt with either the products of bacterial activities without reference to the number of organisms present or with only an enumeration of the bacteria present in the soil. This paper presents the results of an investigation taking into consideration both nitrates and bacterial numbers, as well as a correlation of the two, under certain specific conditions.

Historical Review—Nitrification.

The difficulties attendant upon keeping an adequate supply of available nitrogen in the soil are so great that those bacterial activities which have to do with nitrate formation are important and have been extensively studied. As early as 1660 Digby (2)¹ mentioned the value of nitrates in agriculture. He attributed the growth of plants to the "nutritional and attractive" powers of a "nitrous salt." Many agricultural writers of the early part of the nineteenth century followed the lead of Liebig, who claimed that nitrogen was not needed as a soil amendment. In 1856 Boussingault and Ville (8) independently published experimental results which proved that nitrates are markedly beneficial to plant growth, but it was not until 21 years later that Schloesing and Muntz (22) demonstrated that nitrification in the soil was due to organized ferments and does not take place in the absence of these ferments.

*Reprint from Agricultural Research, 1919, Vol. XVI., No. 2, p. 27.

Nitrification in soils is dependent upon several different factors, and chemists have not entirely agreed as to the conditions necessary for it to take place. It was early observed that calcareous material was necessary for the preparation of niter beds. Thouvenel (4) in 1787 found chalk and carbonate of lime to favor nitrification more than a number of earths and other chemicals. From the accumulated evidence that carbonate of lime increased nitrate formation and the fact that acid forest soils often contained no nitrates the conclusion was reached by many investigators that nitrification did not take place in an acid soil. In 1891 Warington (25, p. 51) said:

A further condition of nitrification is the presence of a base with which the nitric acid when formed may combine. This condition is quite essential. Nitrification can only take place in a feebly alkaline medium.

A little later in 1894 Deherain (8) (p. 360) made the following statements:

The nitric ferment does not act in an acid medium * * *
It is true that nitrification may go on in soil deficient in lime
* * * Moreover, the application of carbonate of lime to
such soils is very beneficial and increases the production of
nitrates.

Nitrates in Acid Soils.

Twenty-two years before Warington (26) stated that nitrification could only "take place in a feebly alkaline medium" Houzeau (12), in 1872, reported nitrification in an acid soil. In 1908 Hall, Miller, and Gimingham (11) found nitrates in an acid soil, but believing that nitrification could not take place in an acid medium, they attributed the phenomena to the probable presence in the soil of small isolated particles of calcium carbonate. Since 1908 several workers have reported nitrification in acid soils. In 1913 Petit (21) found pronounced evidence of such a condition, while the same year Abbott, Conner, and Smalley (1) reported the presence of large amounts of nitrates in an excessively acid soil. The water extract of the soil was acid in reaction and contained considerable aluminium. The next year Temple (23) reported nitrification in acid or non-basic soils. White (26) in 1915 from investigations on some unlimed and limed plots at the Pennsylvania Station found that nitrification was very active in many very acid areas. White remarks that—

These results are entirely contrary to the general belief that nitrification ceases on very acid soils.

Since nitrification is the result of oxidation reactions and due to bacteria, it is affected by soil moisture and aeration. Schlosing (8), in 1868, found that rapid loss of nitrates occurred when a moist "humic soil" was kept in an atmosphere of nitrogen gas. Warrington (25) in experiments at Rothamsted in 1880 found that saturating ordinary soil with water caused it to rapidly lose the nitrates it contained. Kellner (14) in 1891 and Kelley (13) in 1914 found that flooded rice fields contained little or no nitrates.

Bacterial Numbers.

The conditions under which studies of the number of bacteria present in soils have been made have varied to such an extent that generalizations rather than specific correlations have resulted. Chester (6) was the first to note that applications of lime increased the bacterial content of soils. He concluded that the favorable action was not due to any direct action of the lime, but due to the more favorable reaction which the lime gave the soil.

Later Fabricius and Feilitzen (10), Engberding (9), and Brown (5) reported increased bacterial numbers as the result of liming. Engberding showed that in most cases a lack of lime accounted for low bacterial counts.

Kossowicz (16) summarizes the results of investigations by Houston, Th. Remy, Fabricius, and Feilitzen and C. H. Hoffman, as follows:

Manuring brings about an increased bacterial content and betters the conditions for the development of those organisms already present in the soil. The time of the year and weather conditions influence the bacterial content of the soil.—Translation.

Koch (15), Adametz (18) and others have shown that the majority of soil microflora consist principally of rod-shaped organisms. That anaerobic bacteria are present in great numbers has been shown by Ucke (24), who found over 13,000,000 anaerobes present in a garden soil.

Lohnis (18) states that the multiplication of soil organisms varies with different soil layers, and the number of bacteria present decreases with the depth, air and food being the first considerations.

Present Investigations.

Many uncontrolled conditions, such as variations in temperature, moisture, and aeration, are constantly occurring in field practice. The data reported in this paper were obtained in order to ascertain the differences in bacterial numbers, nitrates, and nitrification of five variously treated typical acid

soils, after these soils had been kept for 10 months under the same temperatures and controlled moisture conditions in pots where nitrates could not be lost by leaching. The soils used were all very acid and varied widely in organic matter. They were: (1) A yellow silty clay containing 0.7 per cent of humus, 0.07 per cent of nitrogen; (2) a whitish silt loam containing 1.3 per cent of humus, 0.12 per cent of nitrogen; (3) a brown silt loam containing 3.1 per cent of humus, 0.22 per cent of nitrogen; (4) a black peaty sand containing 5 per cent of humus, 0.4 per cent of nitrogen; and (5) a dark-brown peat containing 52 per cent of humus, 2.04 per cent of nitrogen. More complete analyses of these soils and the changes in their acidities due to moisture changes are given by one of us in another paper (7).

Preparation of Soils.

To obtain soils for the pot tests, quantities of field soil were taken from the surface 6 inches, sacked, transferred to the station where each soil was mixed over and over without drying, sieved, and potted. Equal weights of a soil were put in galvanized-iron paraffined culture pots 9.25 inches in diameter and 11 inches high. The soil was compacted to that of a good seed bed by dropping the pots a prescribed number of times onto the floor from a height of about 3 inches. The pots were kept in the greenhouse and maintained at the desired moisture contents by weighing two to three times a week and replenishing the evaporated moisture with pure distilled water through an open tube extending from above the surface of the soil to an arch at the bottom of the pot. The surface of the soils of all pots except those kept fully saturated with water was cultivated from time to time to give a very thin dust mulch. The wheat stubble and growing clover were in the pots when sampled. The samples were taken to represent the entire depth of soil in the pot by the use of Noyes' bacteriologists' soil samples (19), and all determinations were made from these samples.¹

Nitrates and Nitrification With Lime and Fertilizer Treatments.

The nitrates were determined by the phenoldisulphonic-acid method modified for the accurate determination of soil nitrates.² The results are held to be equally accurate for all

¹The pots used in this investigation were chosen from a series of different investigations on soil-acidity problems, and hence the lime and fertilizer treatments for each soil were not the same.

²Noyes, H. A. The Accurate Determination of Soil Nitrates by the Phenol Disulphonic-Acid Method. To be published in Jour. Indus. and Engin. Chem.

the soils, since the modified method takes into consideration the obtaining of a clear solution, the presence of soluble salts and interfering organic matter. The nitrification tests were made by the beaker method. One hundred gm. of each soil before incubation showed that nitrification had taken place in half-pint jelly glasses. Five cc. of a 2 per cent ammonium-sulphate solution were added and the soil was incubated for six weeks at 20° to 21° C. The moisture content at the end of the period of incubation was in every case within 1 per cent of what it was when the soils were sampled. Table I gives the acidity, crop yields, and nitrate data for each soil with the different lime and fertilizer treatments.

The quantities of nitrates found in the untreated soils before incubation showed that nitrification had taken place in every one of the acid soils. The amounts of nitrate present in the untreated soils when sampled were in proportion to their total nitrogen contents rather than in any relation to their acidities. The presence of growing clover in some of the pots lowered the ratio of the nitrates before incubation to those after incubation. Those pots which contained large growths of clover when sampled and which had received applications of lime alone contained less nitrates than the unlimed pots, which contained little or no clover. This shows that the nitrates present in the soils were greatly influenced by the growing crop. The limed pot in the brown silt-loam series was no exception to this, as the untreated soil on this series grew good clover. With each soil the amounts of nitrates found after incubation were very much greater with lime than without lime, proving that calcium carbonate promotes nitrification in acid soils. As a rule, the less clover there was per pot the greater the ratio of nitrates before incubation to nitrates after incubation.

TABLE I.—Effects of lime and fertilization on nitrates and nitrification of five typical acid soils.

Kind of soil and treatment per million pounds of soil	Acidity. ¹		Crop Yields. ²		Nitrates.			Ratio before and after incubation
	Potassium nitrate	Calcium acetate	Wheat	Clover	Before incubation	After incubation	Increase on incubation	
Yellow Silty Clay.			Gm.	Gm.	P.p.m.	P.p.m.	P.p.m.	
No treatment	2,460	4,000	7	0	10	24	14	42
2 tons of calcium carbonate	20	750	10	14	Tr.	32	32	0
Nitrogen, phosphorus, potassium ³	2,800	4,125	43	2	Tr.	Tr.	0	100
Nitrogen, phosphorus, potassium, 32 tons of calcium carbonate	20	750	68	17	0	184	184	0
Nitrogen, phosphorus, potassium, 36 tons of calcium carbonate	0	500	76	15	9	873	873	0
Whitish Silt Loam.								
No treatment	1,360	3,000	23	13	19	38	19	50
3 tons of calcium carbonate	20	500	40	37	17	879	862	2
500 pounds of acid phosphate	1,380	3,000	23	6	29	48	19	60
Brown Silt Loam.								
No treatment	460	3,750	19	20	23	92	69	25
3 tons of calcium carbonate	20	750	29	30	52	852	800	6
500 pounds of acid phosphate	460	3,750	20	31	19	119	100	16
Black Peaty Sand.								
No treatment	1,800	6,750	0.5	0	350	340	—10	103
2 tons of calcium carbonate	80	3,500	17	11	77	585	508	13
Nitrogen, phosphorus, potassium ³	1,760	6,750	2	1	305	473	168	64
Nitrogen, phosphorus, potassium, 32 tons of Calcium carbonate	40	3,000	35	13	52	913	861	6
Nitrogen, phosphorus, potassium, 36 tons of calcium carbonate	10	750	52	14	233	1,280	1,047	18
Dark-Brown Peat.								
No treatment	2,040	35,000	0	0	710	710	0	100
2 tons of calcium carbonate	1,260	27,500	0.5	0	1,216	1,280	64	95
20 tons of calcium carbonate	100	9,250	48	14	154	4,736	4,582	3

¹Acidity determinations were made by Hopkins potassium-nitrate method and C. H. Jones calcium-acetate methods, and expressed in calcium-carbonate requirements per million.

²Crop yields are given in grams per pot; average of two pots.

³Chemically pure salts: 91 pounds of ammonium nitrate, 72 pounds of ammoniumphosphate, and 100 pounds of potassium phosphate on yellow silty clay. No ammonium nitrate was used on black peaty sand.

The yellow silty clay containing 0.07 per cent of nitrogen and the black peaty sand containing 0.40 per cent of nitrogen received the same lime and fertilizer treatments, but gave quite different crop yields, nitrates, and nitrification. These variations cannot be entirely correlated with changes in soil acidity. On the yellow silty clay it took both lime and fertilizer to give before incubation showed that nitrification had taken place in contained little or no clover. This shows that the nitrates received the same lime and fertilizer treatments, but gave quite a markedly increased nitrifying power, while the black peaty sand, of higher initial nitrifying power, lime gave the large, increased nitrifying power.

The whitish silt loam containing 0.12 per cent of nitrogen received the same lime and acid-phosphate treatment as the brown silt loam containing 0.22 per cent of nitrogen. Lime increased nitrification on both these soils more than acid phosphate did.

Soil Moisture in Relation to Nitrates and Nitrification.

In order to ascertain what effect keeping soils at different moisture contents without crop would have on the nitrates present in the soil and nitrification tests, samples were drawn from a series of pots where each of the five acid soils had been kept at different moisture contents. The nitrates present in the soils after standing 10 months with specified moisture contents are given in Table II.

TABLE II.—Effects of variable moisture on nitrates and nitrification of five typical acid soils.

Kind of Soil and Moisture Treatments.	Acidity. ¹		Nitrates.			Ratio before and after incubation.
	Potassium nitrate.	Calcium acetate.	Before incubation.	After incubation.	Increase on incubation.	
Yellow Silty Clay.						
One-half	3,075	4,500	P. p. m. 24	P. p. m. 19	P. p. m. 5	126
Full	1,740	3,125	0	0	0	.....
Whitish Silt Loam.						
One-fourth	1,550	3,125	136	82	—54	166
One-half	1,860	4,500	74	128	54	58
Full	888	2,750	0	0	0	.....
Brown Silt Loam.						
One-fourth	325	4,500	265	100	—165	265
One-half	487	5,000	319	122	—197	261
Full	225	2,500	0	0	0	.....
Black Peaty Sand						
One-fourth	1,560	6,500	140	328	188	43
One-half	1,810	6,250	315	190	—125	166
Full	925	4,750	0	0	0	.....
Dark-Brown Peat.						
One-fourth	2,000	31,750	178	214	36	83
One-half	2,700	32,500	618	766	148	81
Full	3,360	34,750	0	0	0	.....

¹Both methods are expressed in calcium-carbonate requirement per million.

The results given in Table II show that the amount of water present in a soil is concerned with its nitrification; and further, that soils fully saturated with moisture do not contain nitrates either before or after incubation with ammonium sulphate. This table shows even more strongly than Table I that nitrification takes place in an acid soil, for the nitrates contained in the soils when sampled varied directly with the organic matter content of the different soils, but did not increase with lower soil acidities. The many instances where the nitrates in the soil when sampled were greater than those after incubation show that the nitrates present in these uncropped soils were near the maximum that could be present under the conditions of the experiment.

Method of Obtaining Counts

Field conditions are variable, and the results of these variations are apparent in the soil processes, due to bacterial agencies. It was believed that bacterial counts properly made would show some correlations among these different acid soils, the lime and fertilizer treatments, and the variable moisture contents they were kept under. Not only the nitrifying organisms but all classes of organisms had been given 10 months to respond to the different treatments, and an enumeration of both aerobes and anaerobes should show the types of bacteria predominating under the different treatments.

Plate counts were made from plates of high bacterial dilutions of each treatment according to the technic of Noyes and Voigt (20). Unpublished work by one of us on aerobic and anaerobic soil bacteria has shown that the average of five plates of a bacterial dilution high enough so that all bacteria from 1 cc. of the dilution will have a chance to develop into colonies in 10 days, gives accordant results. The media used was Lipman and Brown (17) modified synthetic agar, which extensive tests have proved to be satisfactory for the development of soil micro-organisms. The carbon dioxid and hydrogen incubations were carried out in an atmosphere of flowing hydrogen or carbon-dioxid gas.

Aerobic and Anaerobic Counts on Cropped, Limed, and Fertilized Soils.

The number of bacteria present under the different lime and fertilizer treatments are given in Table III.

Table III shows that large increases in bacterial numbers result from the use of lime. These increases are largely in the aerobic organisms, although with the soils that contain considerable partially decomposed organic matter the anaerobic count is also increased.

Representative aerobic plates obtained from the yellow silty clay are shown in Plate 1. The numbers of colonies per plate are small, allowing for maximum development; yet no striking differences in kinds of microorganisms are apparent under the different treatments. Neither lime nor complete fertilizer alone had any great influence on bacterial numbers, while complete fertilizer with 2 tons of lime more than doubled the bacterial index (sum of aerobes and anaerobes) of the soil. Six tons of lime with fertilizer did not increase the bacterial index (sum of aerobes and anaerobes) of the soil. Six tons of lime with fertilizer did not increase the bacterial index as much as the 2 tons with fertilizer.

TABLE III.—Effects of lime and fertilization on bacterial content of five typical acid soils.

Kind of soil and treatment per million pounds of soil.	Millions of bacteria per gram of dry soil.		Bacterial index. ¹	Increase of bacterial index due to—	
	Air incu- bation.	Hydrogen incubation.		Calcium carbonate.	Fer- tilizer.
Yellow Silty Clay.					
No treatment	23.010	0.100	3.110	.....	.....
2 tons of calcium carbonate..	3.046	.381	3.427	0.317	.....
Nitrogen, phosphorus, potas- sium ³	3.027	.000	3.027	.....	—0.083
Nitrogen, phosphorus, potas- sium, ³ 2 tons of calcium carbonate	7.605	.000	7.605	4.578	4.178
Nitrogen, phosphorus, potas- sium, ³ 6 tons of calcium carbonate	5.244	.000	5.244	2.217	.....
Whitish Silt Loam.					
No treatment	5.021	1.545	6.566	.....	.....
3 tons of calcium carbonate..	14.810	.898	15.708	9.142	.....
500 pounds of acid phosphate	5.531	.000	5.531	.....	—1.035
Brown Silt Loam.					
No treatment	9.904	.189	10.093	.....	.....
3 tons of calcium carbonate..	23.921	2.556	26.477	16.384	.....
500 pounds of acid phosphate	11.164	2.714	13.878	.....	3.785
Black Peaty Sand.					
No treatment	3.146	1.154	4.300	.....	.....
2 tons of calcium carbonate..	8.336	1.617	10.003	5.703	.....
Black Peaty Sand.					
Nitrogen, phosphorus, potas- sium ²	2.813	2.907	5.720	.....	1.420
Nitrogen, phosphorus, potas- sium, 2 tons of calcium carbonate	10.583	.099	10.682	4.962	.679
Nitrogen, phosphorus, potas- sium, 6 tons of calcium carbonate	16.037	1.760	17.797	12.077	.....
Dark-Brown Peat.					
No treatment	1.554	.997	2.551	.....	.....
2 tons of calcium carbonate..	3.420	1.440	4.860	2.309	.....
20 tons of calcium carbonate	91.846	11.752	103.598	101.047	.....
Average.....	12.109	1.535	13.694	15.874	.....

¹Sum of air and hydrogen counts.

²Average of five plates. No count indicates no colonies on plates from 1:400,000 bacterial dilutions.

³Chemically pure salts: 91 pounds of ammonium nitrate, 72 pounds of ammonium phosphate, and 100 pounds of potassium phosphate on yellow silty clay. No ammonium nitrate was used on black peaty sand.

Lime more than doubled the bacterial indexes of the whitish silt and brown silt loams. Acid phosphate decreased the anaerobic counts of the whitish silt loam enough more than it increased the aerobic contents so that the bacterial index was decreased. With the brown silt loam containing considerable undecayed organic matter the acid phosphate increased both the aerobic and anaerobic counts somewhat. Plate 2 shows representative petri plates from each treatment for the two soils. This plate shows a marked similarity between the colonies on the aerobic plates from the limed pots of both soils. The similarity of the appearances of the plates from the limed and the phosphated pots of the whitish silt loam, the similarity of all aerobic plates from the brown silt loam and the uniformity of colonies developing from the brown silt loam under anaerobic conditions are to be noted.

The black peaty sand containing six times as much nitrogen as the yellow silty clay, received the same lime and fertilizer treatments as the yellow clay, but gives entirely different results. Lime and fertilizer both alone and in combination give increased bacterial indexes. While the aerobic organisms are increased by lime, the organic matter of the black peaty sand must be in an advanced stage of decay since the counts are lower than they should be if the organic matter was good food for bacteria. Plate 3 shows representative culture plates from this soil. These illustrations emphasize the effect of lime on bacterial numbers and the small proportion of the bacteria which are anaerobic.

The dark-brown peat shows an increase of over 100,000,000 in bacterial index as the result of liming. Peats *in situ* are generally low in bacterial content. Working them over after drainage generally causes enormous increases in their bacterial content. This peat, even when aerated, had only $11\frac{1}{2}$ times as many aerobic as anaerobic bacteria, but adequate liming increased the aerobes more than 60 times and the anaerobes over 11 times. The increase in anaerobes is believed to be associated with the large amount of organic matter present in the soil. Plate 4 shows representative petri plates of the colonies developing in air and hydrogen. Attention is called to the small variation in colony types on the anaerobic plates as compared to the aerobic. The aerobic culture plates from the heavily limed soil showed many chromogenic differences between colonies not observable in the photographs.

Soil Moisture in Relation to Bacterial Counts.

In addition to the incubations in air and hydrogen another set of plates was incubated in an atmosphere of flowing

carbon-dioxid gas for 10 days. No colonies developed on this set of plates while they were in carbon-dioxid gas. The counts given were computed from colonies developing in 10 days in air after the plates had been removed from the carbon dioxid.¹

Table IV gives the counts under the different conditions of incubation and the various soil-moisture contents.

TABLE IV.—Effects of variable moisture on bacterial content of five typical acid soils.

Kind of soil and degree of moisture saturation.	Millions of bacteria per gram of dry soil.			Bacterial index. ²	Ratios to bacterial indexes as 100.		
	Air.	Hydro-gen.	Carbon-dioxid-surviv-ing. ¹		Air.	Hydro-gen.	Carbon-dioxid-surviv-ing.
Yellow Silty Clay.							
One-half	31.556	0.101	0.131	1.657	94	6	8
Full .....	.184	.032	.075	.216	85	15	35
Whitish Silt Loam.							
One-fourth	2.792	.367	.282	3.159	88	12	9
One-half	3.688	1.171	.216	4.859	76	24	4
Full	3.179	.353	.346	3.532	90	10	7
Brown Silt Loam.							
One-fourth	4.920	1.879	.533	6.799	72	28	8
One-half	4.513	1.640	.847	6.153	73	27	14
Full	7.854	2.864	.575	10.718	73	27	5
Black Peaty Sand.							
One-fourth	1.641	.453	.286	2.094	78	22	14
One-half	2.363	1.270	.463	3.633	65	35	13
Full	3.316	.129	1.071	3.445	96	4	31
Dark-Brown Peat.							
One-fourth	2.425	1.988	1.101	4.413	55	45	25
One-half	1.796	1.914	1.204	3.710	48	52	33
Full	2.257	.735	.499	2.992	75	25	17
Average.....	3.034	1.064	.538	4.098	74	26	13

¹Incubated 10 days in carbon dioxid; then 10 days in air.

²Sum of air and hydrogen incubation.

³All figures were computed from 5 plates.

The bacterial content, as well as the proportions of aerobes to anaerobes, was changed by the degree of saturation of the soil, but the nature of the soil had a greater effect than the moisture content on bacterial numbers. The proportions of anaerobes to the aerobes which survived carbon-dioxid incubation increased with soil organic matter when the soils were held under optimum moisture conditions.

¹These organisms, as far as tested, have been found to be spore formers.

Plates 5 to 9 show representative petri plates from the 1 to 40,000 bacterial dilution of these soils. Figures A₁, H₁, and C₁ in each plate show representative petri plates after air (A), hydrogen (H), and carbon-dioxid, then air (C) incubations of bacterial dilutions of samples from pots of soils kept one-fourth saturated with water. Figures A₂, H₂, and C₂ are from samples from pots of soils kept fully saturated, while A₃, H₃, and C₃ are from pots of soils kept fully saturated with water.

Plates 5 to 9 show that the bacterial flora of each soil is

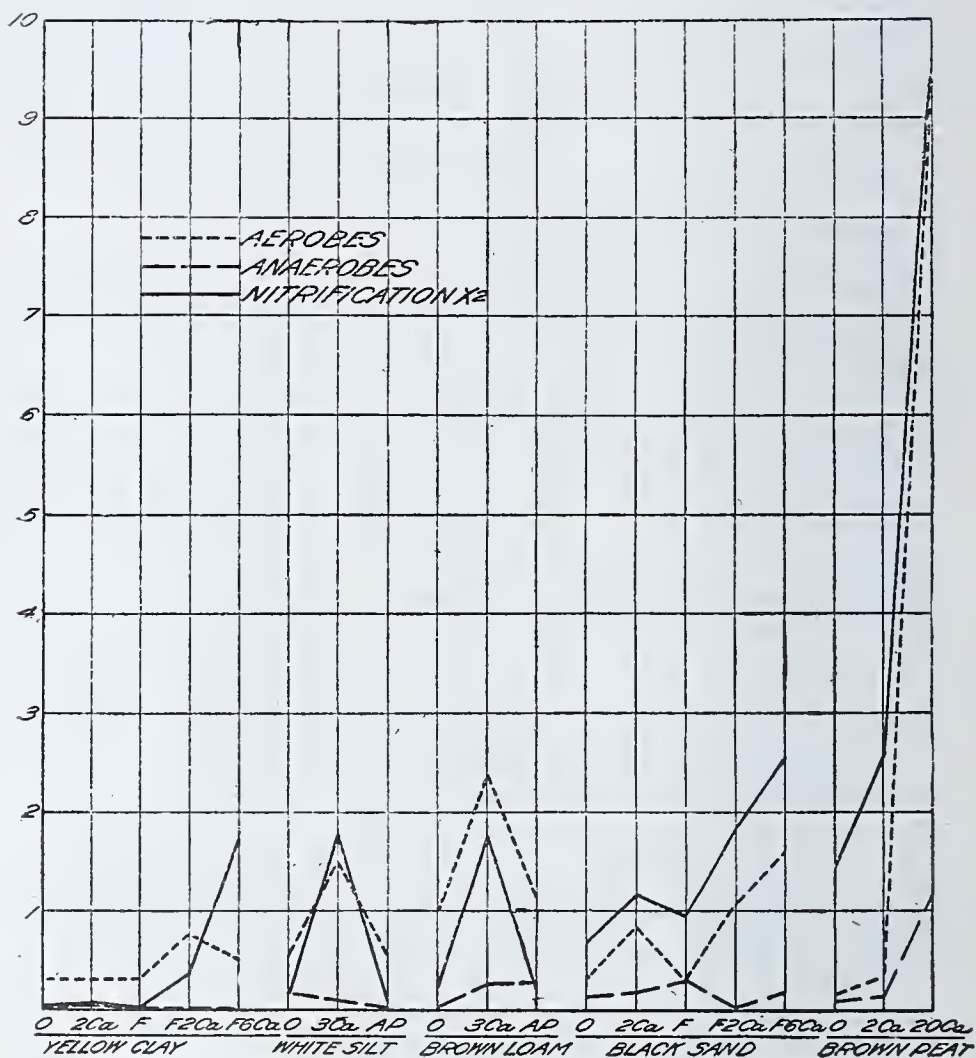


Fig. 1.—Graphs showing the relation of aerobes and anaerobes to nitrification of five acid soils with and without lime and fertilizer treatments.

different from that of every other soil. The soils kept one-fourth saturated with water contained the largest numbers of micro-organisms developing mold-like colonies, and the fully

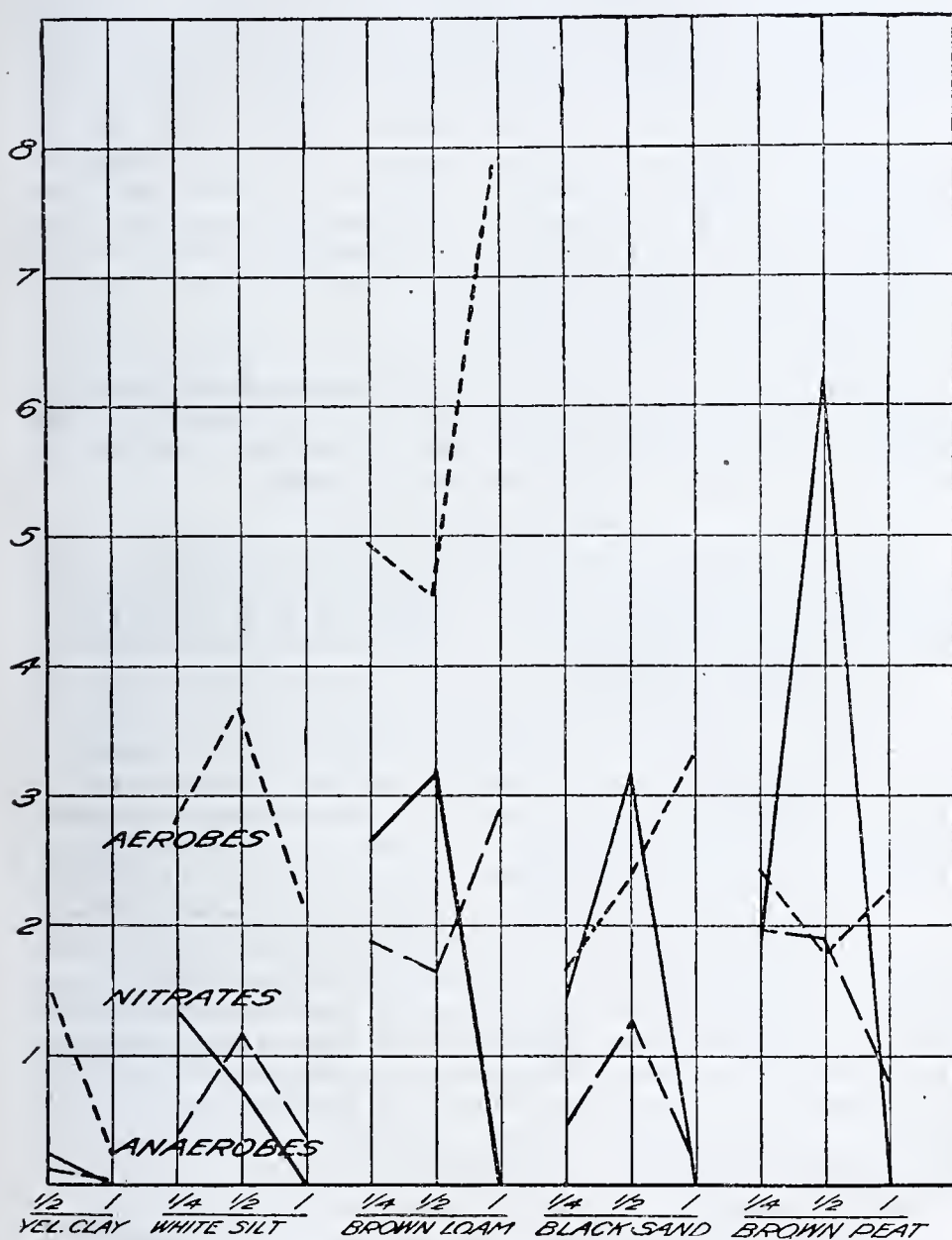


Fig. 2.—Graphs showing the relation of aerobes and anaerobes to nitrates in five acid soils kept at different moisture contents.

saturated soils gave culture plates containing the smallest numbers of spreading moldlike colonies.

Nitrates and Nitrification in Relation to Bacterial Counts.

Lime increased both nitrification and bacterial counts. A study of Plates 1 to 4 shows that the increases in bacterial numbers can be associated principally with the aerobic small, round, entire colonies on the petri plates. Figure 1 shows the relations between Aerobic and anaerobic bacteria and the nitrates after incubation for the cropped, limed, and fertilized soils kept at optimum moisture content. The nitrates after incubation varied directly with the aerobic bacteria. The aerobic count and nitrates after incubation show that it is the increased number of aerobic organisms that are to be associated with increased nitrification.

Figure 2 gives soil nitrates, aerobic, and anaerobic bacterial numbers for the series of soils where moisture was the variable. These graphs shows that lack of aeration which changed the proportions of aerobes to anaerobes prevented a correlation between nitrates and aerobic counts.

General Discussion.

After conducting bacteriological investigations on acid soils to ascertain "if it might be desirable to consider more carefully the possibilities of a system of acid agriculture," Bear (3) concluded that—

The supply of nitrogen in acid soils may be maintained by growing acid-resistant legumes, of which the soy bean is one. Undoubtedly the use of acid phosphate aids materially in the nitrogen-fixation processes of acid soils. Small applications of calcium carbonate are, as a rule, relatively more effective than large applications as a means of increasing the bacterial activities in acid soils.

The problem of maintaining soil fertility resolves itself into maintaining and increasing the available supply of organic matter and nitrogen in the soil and the replenishing of the mineral elements. One system now generally recommended and used is to apply lime and phosphates, then to grow legumes, and to plow them under. This system of soil maintenance and improvement is in accordance with the important role of soil bacteria in plant nutrition, and the results obtained in the controlled investigations reported here illustrate some good reasons for such a method of soil management.

When the soil was limed, the aerobic bacteria concerned with oxidation reactions increased in numbers. This is illustrated by the increased bacterial numbers and nitrification wherever the soils were limed.

Plenty of organic matter is necessary for high bacterial numbers, a condition which is well illustrated by the low bacterial content and nitrate results with the limed yellow silty clay (low in organic matter) compared with the high bacterial contents and nitrates on the limed brown silt loam and dark-brown peat (high in organic matter).

Mineral fertilizers serve as food for large crops and larger crops in turn leave more residues in roots and stubble for bacterial food.

The number of bacteria in an arable soil can be correlated with crop yield to about the same degree that soil moisture can be. Soil moisture is conceded to be the most vital single factor influencing crop yields; yet because of so many other variable conditions it is not always possible to correlate soil moisture and crops any more than it is possible to always correlate bacterial numbers and crops. Below a certain minimum in moisture or bacterial numbers field soils will not produce crops; above that minimum, everything else being equal, crops may be in general correlated with bacterial numbers as well as with moisture.

Changes in bacterial numbers, especially differences in the proportions of aerobes to anaerobes, are of prime importance in soil-biology studies. The results here reported under controlled conditions make it evident that soil-fertility investigations should include both chemical and biological examinations of the soil.

Summary.

(1) Controlled greenhouse investigations were conducted on five typical acid soils. In part of the experiments the soils were fertilized with calcium carbonate, acid phosphate, and complete fertilizer, cropped to wheat and clover, and kept at optimum moisture content, while in another series the soils were unfertilized, uncropped, and kept one-fourth, one-half, and fully saturated with water.

(2) The results reported include crop yields, soil-acidity determinations, nitrates in the soil when sampled and after incubation with ammonium sulphate, and also the numbers of aerobic, anaerobic, and carbon-dioxid surviving micro-organisms present in the soils.

(3) All the untreated soils were quite acid and contained nitrates when sampled, showing that nitrification takes place in acid soils.

(4) The amounts of nitrates present and the nitrifying power of the untreated acid soils varied with the organic matter and total nitrogen rather than with the soil acidity.

(5) Calcium-carbonate additions markedly increased the nitrification of all five soils.

(6) Fertilization tended to increase nitrification, but not so much as calcium carbonate did.

(7) Regardless of treatments the presence of growing clover kept down nitrate contents of the soils.

(8) The degree of saturation of the soils affected the nitrates present. As a rule, more nitrate were found in soil kept one-half saturated with water than in soil kept one-fourth saturated.

(9) The soils that had been kept fully saturated with water for the 10 months contained no nitrates and formed no nitrates when incubated with ammonium sulphate.

(10) The relation of nitrates present in the uncropped soils before incubation to the nitrates present after incubation shows that the nitrate contents of these acid soils tend to reach an equilibrium, above which no increase is obtained without additional treatment.

(11) The bacterial flora of each soil was different from that of every other soil.

(12) No bacteria developed into colonies visible to the eye as long as plates were incubated in an atmosphere of flowing carbon-dioxid gas.

(13) Calcium-carbonate additions increased the bacterial contents of the soils. This increase was largely in the aerobic organisms.

(14) Small increases in bacterial content resulted from the use of fertilizer.

(15) The degree of saturation at which the soil was kept changed the proportions between the aerobic, anaerobic, and carbon-dioxid-surviving bacteria.

(16) Cultures from samples that had been kept one-fourth saturated with water contained the largest proportions of organisms forming moldlike colonies.

(17) Under optimum moisture conditions both without and with lime and fertilizer treatments the nitrates after incubation varied directly with the aerobic counts.

(18) In general, the greater the aerobic bacterial content and the nitrifying power of the soil the larger the crop yields.

(19) These investigations show many reasons why a system of soil improvement which includes the addition of lime, phosphate, and organic matter is worth while.

(20) It is evident that soil fertility investigations should include both chemical and biological examinations of the soil.

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Plate I.

Representative plates from 1 to 400,000 bacterial dilution of
acid yellow silty clay, cropped and held under
optimum moisture conditions:

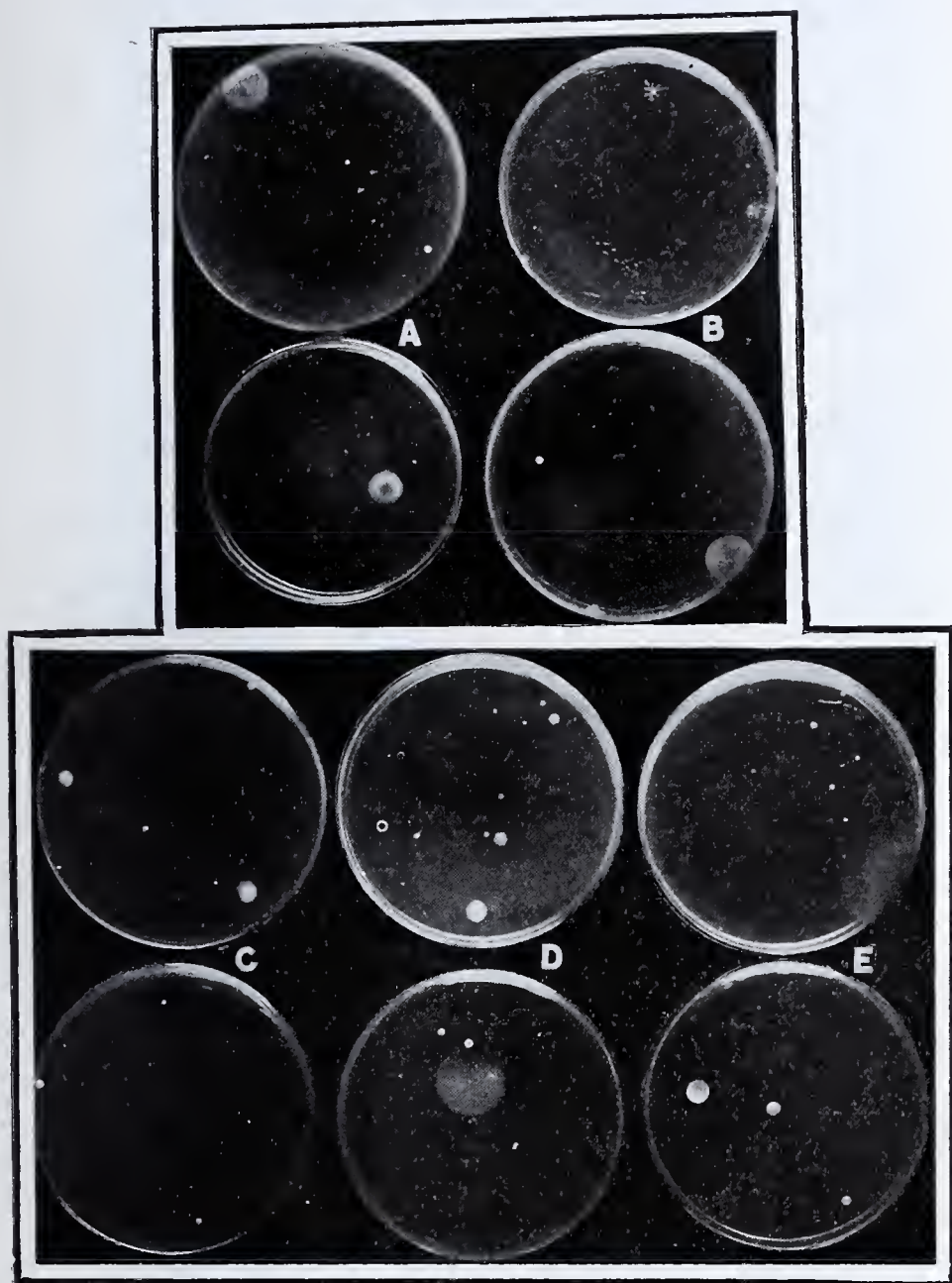
A.—Aerobic plates, untreated.

B.—Aerobic plates, treated with 2 tons of calcium carbonate.

C.—Aerobic plates, treated with complete fertilizer.

D.—Aerobic plates, treated with complete fertilizer and 2 tons
of calcium carbonate.

E.—Aerobic plates, treated with complete fertilizer and 6 tons
of calcium carbonate.



Nitrates, Nitrification, and Bacteria of Acid Soils

Plate 1

Plate 2.

Representative plates from 1 to 40,000 bacterial dilution of acid whitish silt loam and acid brown silt loam cropped and held under optimum moisture conditions:

- A.—Aerobic plates, acid whitish silt loam, untreated.
- B.—Aerobic plates, acid whitish silt loam, treated with 3 tons of calcium carbonate.
- C.—Aerobic plates, acid whitish silt loam, treated with 500 lbs. of acid phosphate.
- D.—Aerobic plates, acid brown silt loam, untreated.
- E.—Aerobic plates, acid brown silt loam, treated with 3 tons of calcium carbonate.
- F.—Aerobic plates, acid brown silt loam, treated with 500 lbs. of acid phosphate.
- G.—Anaerobic plates, acid brown silt loam, untreated.
- H.—Anaerobic plates, acid brown silt loam, treated with 3 tons of calcium carbonate.
- I.—Anaerobic plates, acid brown silt loam, treated with 500 pounds of acid phosphate.

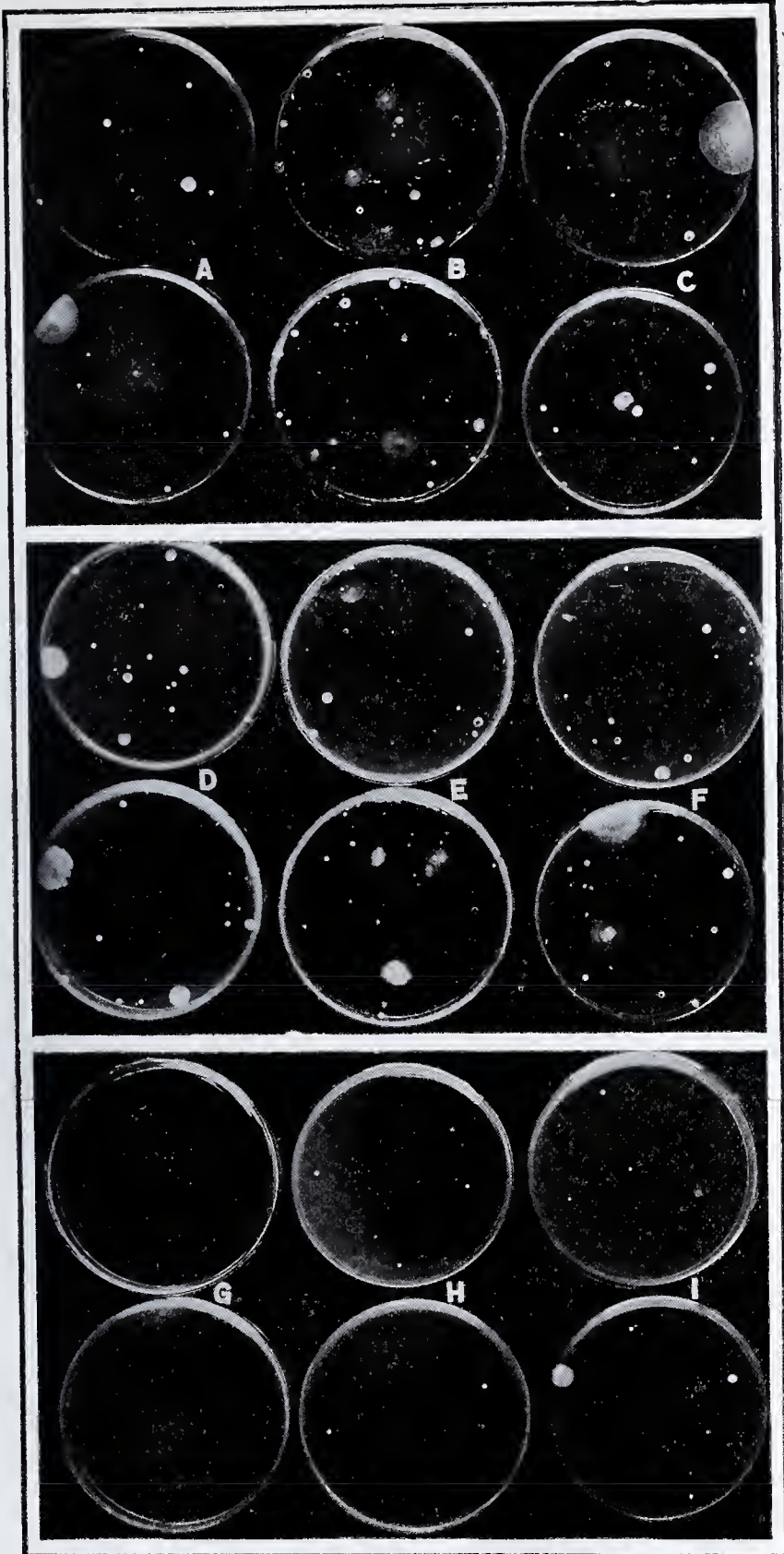
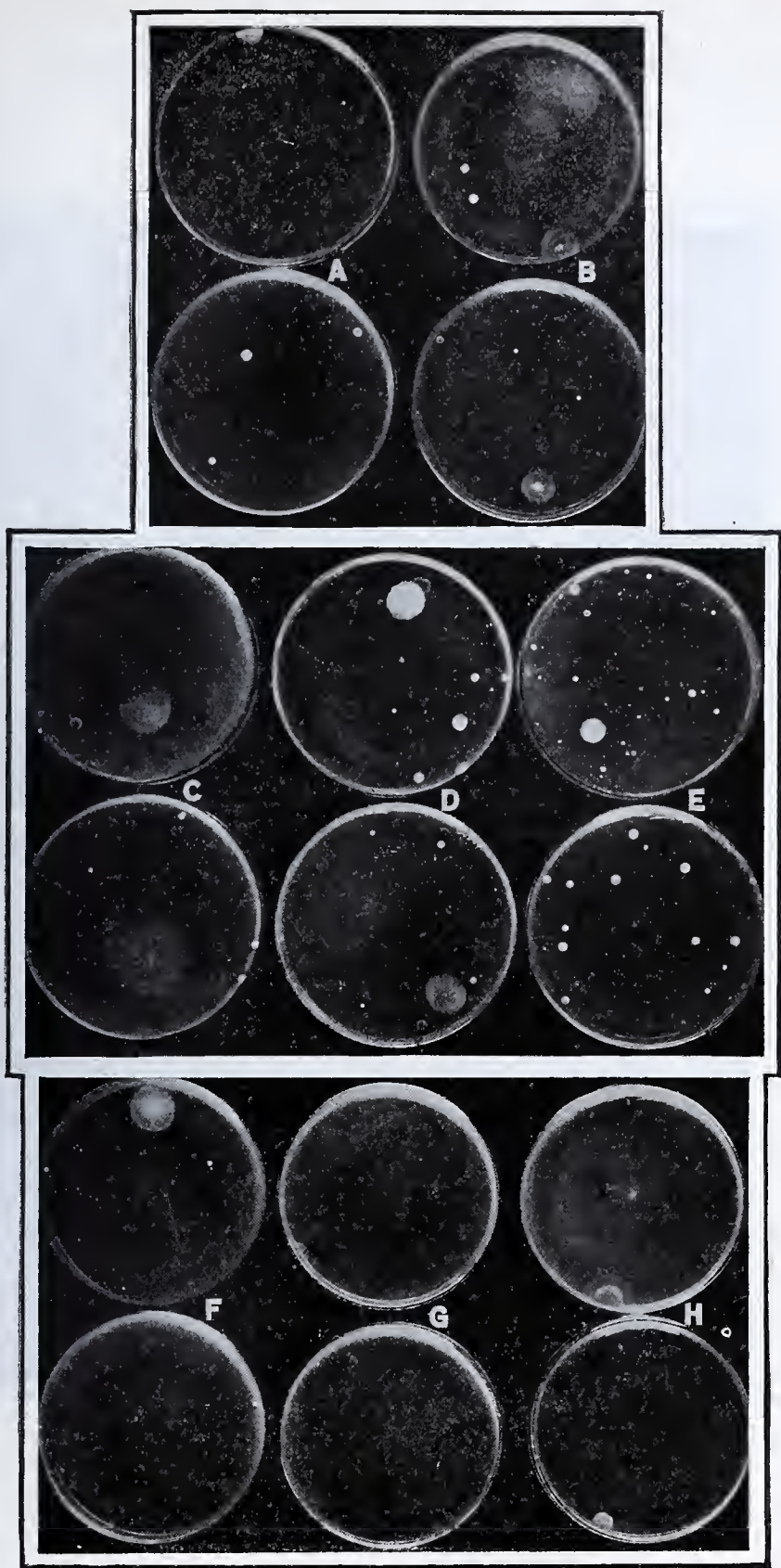
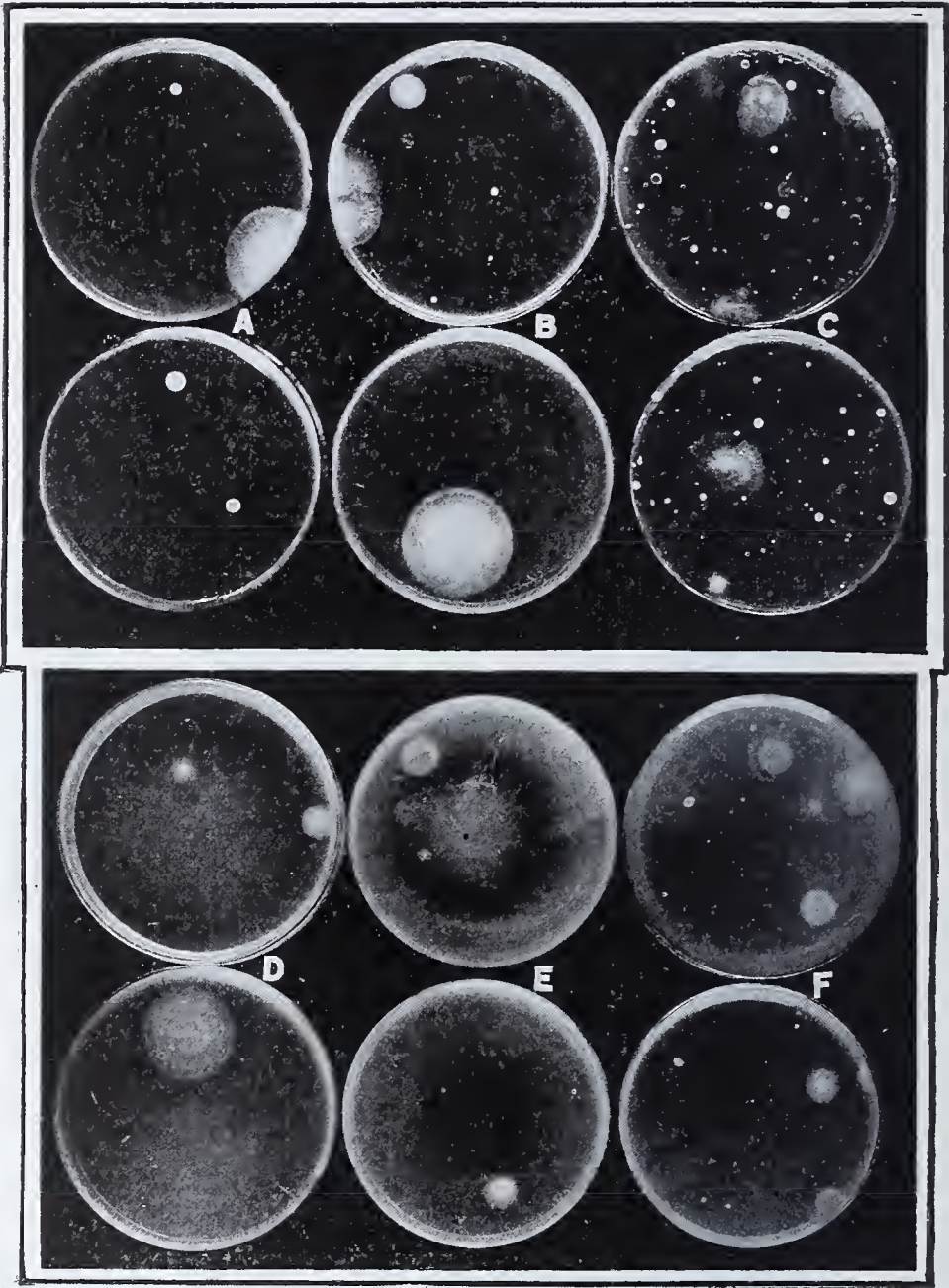


Plate 3.

Representative plates from 1 to 40,000 bacterial dilution of acid black peaty sand, cropped and held under optimum moisture conditions:

- A.—Aerobic plates, untreated.
- B.—Aerobic plates, treated with 2 tons of calcium carbonate.
- C.—Aerobic plates, treated with complete fertilizer.
- D.—Aerobic plates, treated with complete fertilizer and 2 tons of calcium carbonate.
- E.—Aerobic plates, treated with complete fertilizer and 6 tons of calcium carbonate.
- F.—Anaerobic plates, treated with complete fertilizer.
- G.—Anaerobic plates, treated with complete fertilizer and 2 tons of calcium carbonate.
- H.—Anaerobic plates, treated with complete fertilizer and 6 tons of calcium carbonate.





Nitrates, Nitrification, and Bacteria of Acid Soils

Plate 4

Plate 4.

Representative plates from 1 to 40,000 bacterial dilution of
acid dark-brown peat, cropped and held under
optimum moisture conditions:

- A.—Aerobic plates, untreated.
- B.—Aerobic plates, treated with 2 tons of calcium carbonate.
- C.—Aerobic plates, treated with 20 tons of calcium carbonate.
- D.—Anaerobic plates, untreated.
- E.—Anaerobic plates, treated with 2 tons of calcium carbonate.
- F.—Anaerobic plates, treated with 20 tons of calcium carbonate.

Plate 5.

Representative plates from 1 to 40,000 bacterial dilution of acid yellow silty clay kept at different moisture contents:

A₂.—Aerobic plates, from soil kept one-half saturated.

H₂.—Anaerobic plates, from soil kept one-half saturated.

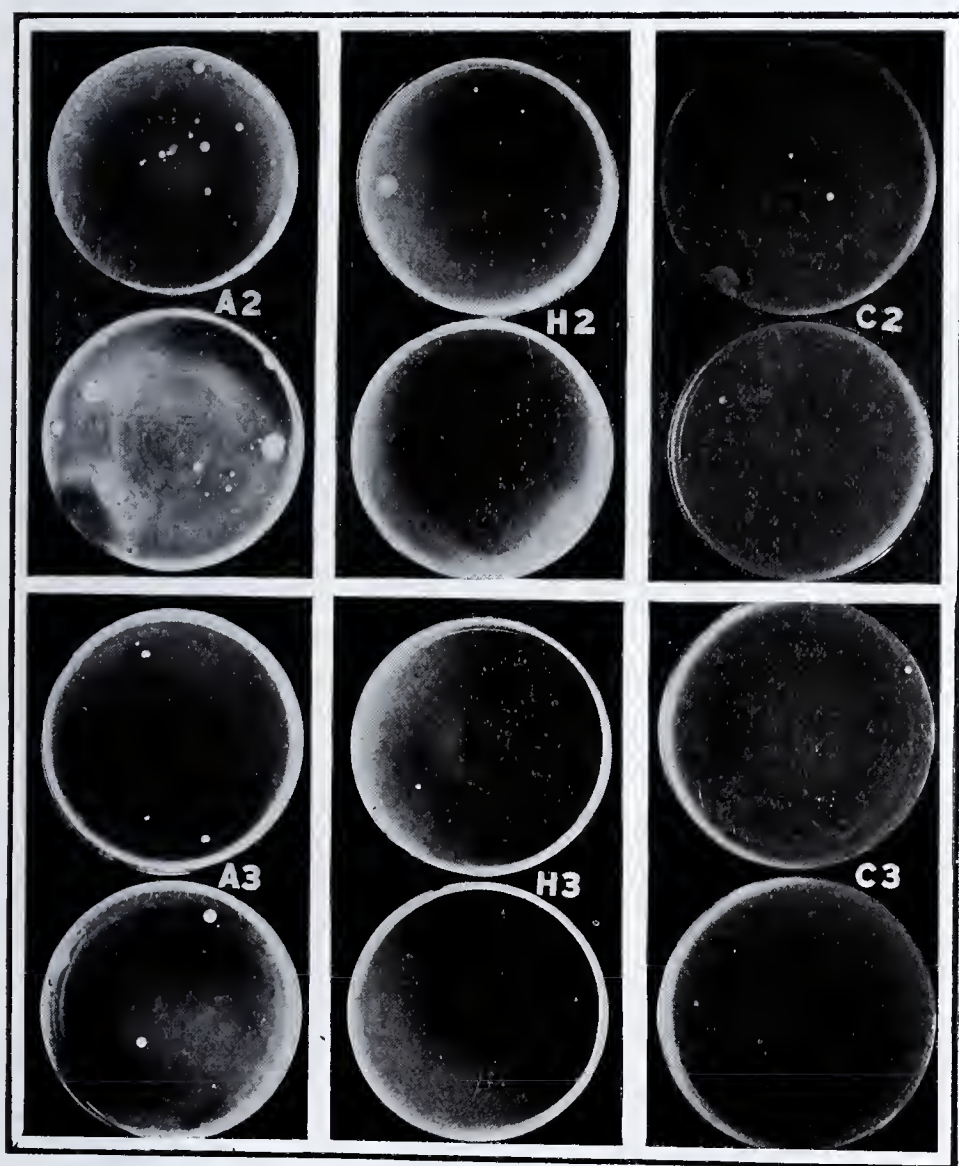
C₂.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept one-half saturated.

A₃.—Aerobic plates from soil kept fully saturated.

H₃.—Anaerobic plates from soil kept fully saturated.

H₃.—Anaerobic plates from soil kept fully saturated.

C₃.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept fully saturated.



Nitrates, Nitrification, and Bacteria of Acid Soils

Plate 5

Plate 6.

Representative plates from 1 to 40,000 bacterial dilution of acid whitish silt loam kept at different moisture contents:

- A₁.—Aerobic plates from soil kept one-fourth saturated.
- H₁.—Anaerobic plates from soil kept one-fourth saturated.
- C₁.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept one-fourth saturated.
- A₂.—Aerobic plates from soil kept one-half saturated.
- H₂.—Anaerobic plates, from soil kept one-half saturated.
- C₂.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept one-half saturated.
- A₃.—Aerobic plates from soil kept fully saturated.
- H₃.—Anaerobic plates from soil kept fully saturated.
- C₃.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept fully saturated.

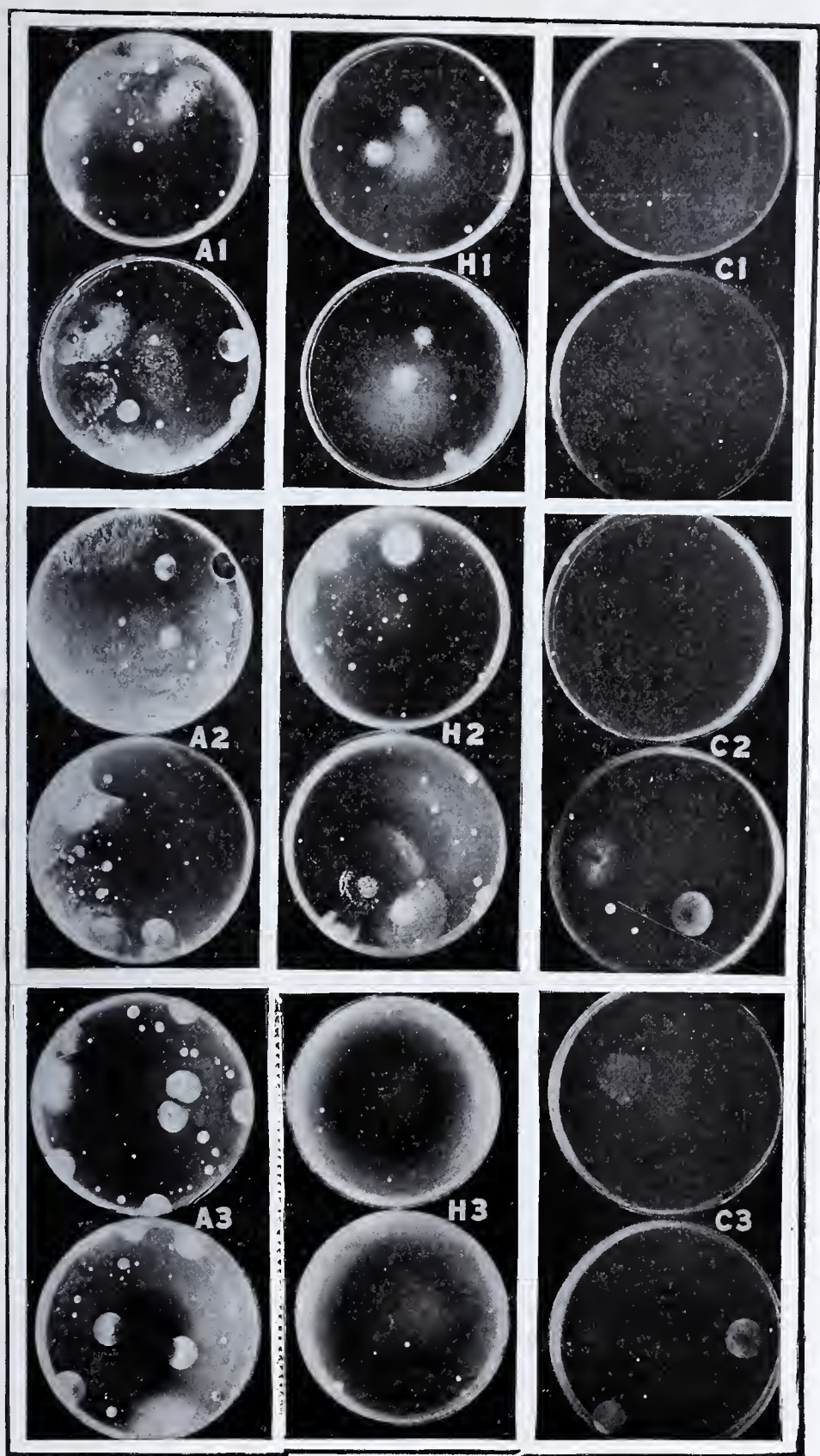


Plate 7.

Representative plates from 1 to 40,000 bacterial dilution of
acid brown silt loam kept at different
moisture contents: :

A₁.—Aerobic plates from soil kept one-fourth saturated.

H₁.—Anaerobic plates from soil kept one-fourth saturated.

C₁.—Aerobic plates of carbon-dioxid-surviving organisms from
soil kept one-fourth saturated.

A₂.—Aerobic plates from soil kept one-half saturated.

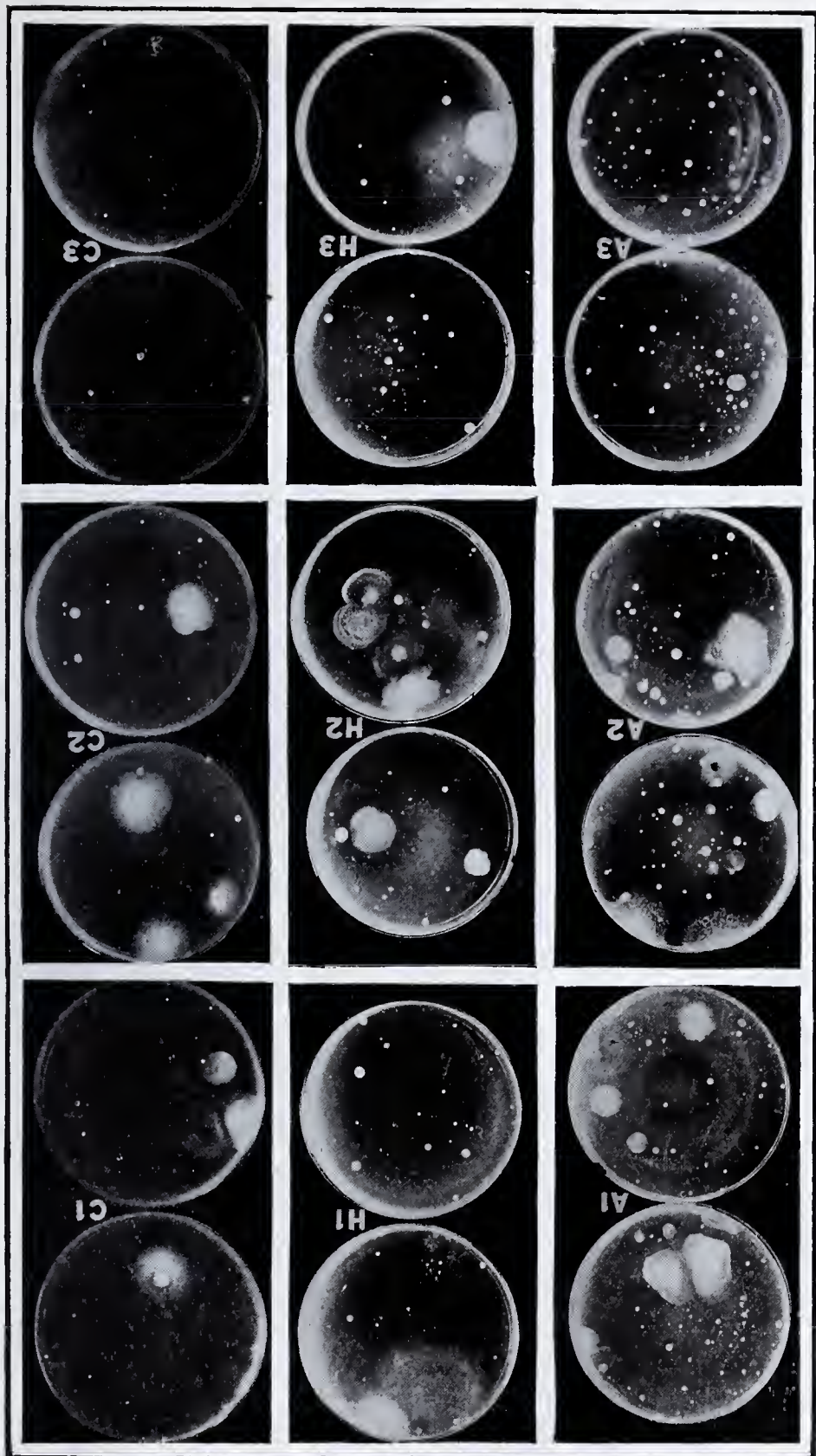
H₂.—Anaerobic plats, from soil kept one-half saturated.

C₂.—Aerobic plates of carbon-dioxid-surviving organisms from
soil kept one-half saturated.

A₃.—Aerobic plates from soil kept fully saturated.

H₃.—Anaerobic plates from soil kept fully saturated.

C₃.—Aerobic plates of carbon-dioxid-surviving organisms from
soil kept fully saturated.



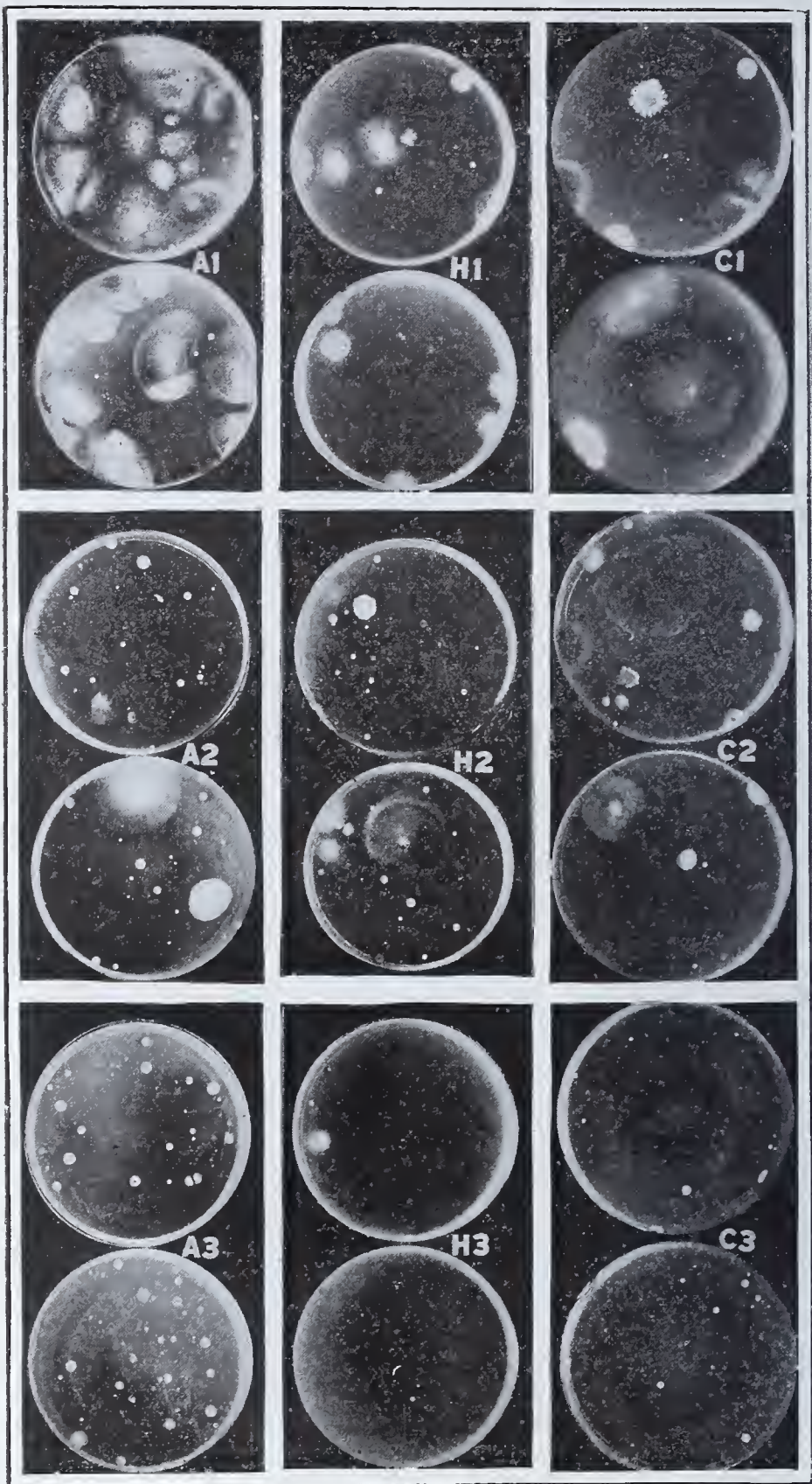


Plate 8.

Representative plates from 1 to 40,000 bacterial dilution of
acid black peaty sand kept at different
moisture contents:

- A₁.—Aerobic plates from soil kept one-fourth saturated.
- H₁.—Anaerobic plates from soil kept one-fourth saturated.
- C₁.—Aerobic plates of carbon-dioxid-surviving organisms from
soil kept one-fourth saturated.
- A₂.—Aerobic plates from soil kept one-half saturated.
- H₂.—Anaerobic plats, from soil kept one-half saturated.
- C₂.—Aerobic plates of carbon-dioxid-surviving organisms from
soil kept one-half saturated.
- A₃.—Aerobic plates from soil kept fully saturated.
- H₃.—Anaerobic plates from soil kept fully saturated.
- C₃.—Aerobic plates of carbon-dioxid-surviving organisms from
soil kept fully saturated.

Plate 9.

Representative plates from 1 to 40,000 bacterial dilution of dark-brown peat kept at different moisture contents:

A₁.—Aerobic plates from soil kept one-fourth saturated.

H₁.—Anaerobic plates from soil kept one-fourth saturated.

C₁.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept one-fourth saturated.

A₂.—Aerobic plates from soil kept one-half saturated.

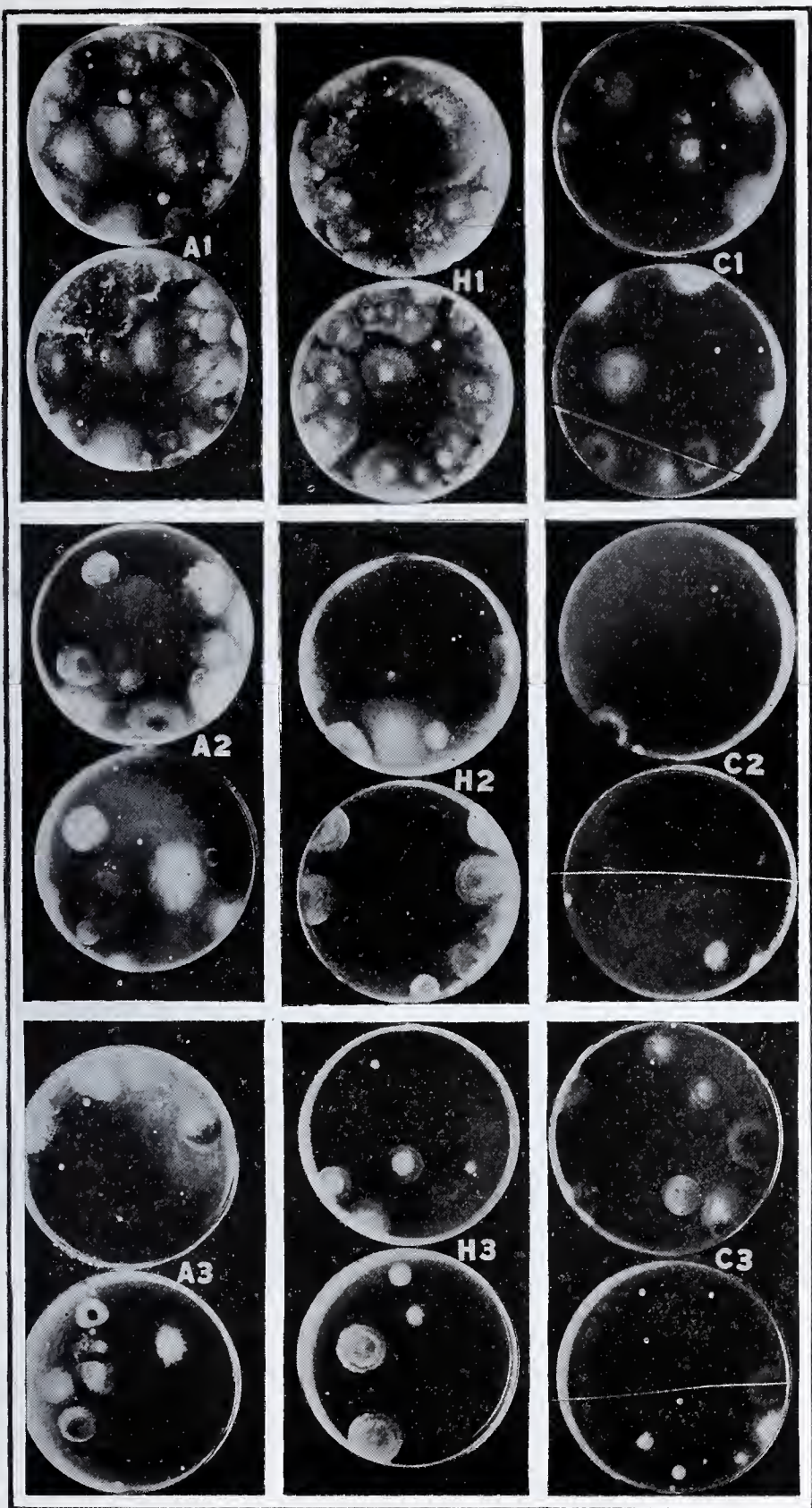
H₂.—Anaerobic plates from soil kept one-half saturated.

C₂.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept one-half saturated.

A₃.—Aerobic plates from soil kept fully saturated.

H₃.—Anaerobic plates from soil kept fully saturated.

C₃.—Aerobic plates of carbon-dioxid-surviving organisms from soil kept fully saturated.



MISTAKES AND FALLACIES IN GREEN-KEEPING.*

By C. V. Piper and R. A. Oakley.

Many questionable practices and erroneous notions prevail in connection with the use of fertilizers on fairways and putting greens. This is particularly true with regard to the use of lime. The functions of lime in plant growth at best are poorly understood, but that lime is not a panacea for all soil or plant troubles is certain. The general feeling in green-keeping is that lime should be used liberally without regard to soil conditions or to the kind of grass with which it is to be used. This fallacy that lime is beneficial to all grasses is widespread and harmful. Some grasses, notably the blue-grasses, are markedly benefited by lime, while some are little, if at all, benefited by it. Among those that respond very slightly to lime are the bents and fescues. The indiscriminate use of lime with these grasses would not be a serious matter, except for the money wasted, were it not for the fact that lime very greatly increases the growth of many weeds that are common in the turf and therefore it actually injures the turf by encouraging weed growth.

As general rules for guidance it should be remembered that where a good growth of Kentucky bluegrass is desired, lime may, and in most cases should be used liberally. It may also be used with beneficial effect, regardless of the kinds of grasses, on soils containing an excessive amount of inactive organic matter such as raw peat, to stimulate nitrification, or in other words, to make the organic matter available to the plants. But in the case of putting greens, nitrogen can be so easily added that it is not highly essential to promote nitrification. However, in some cases where large amounts of raw organic matter are present, lime may act as an amendment or corrective in addition to stimulating nitrifying organisms. Where a fine turf of the bents or fescues is desired, lime should be used very sparingly, if at all, because of its stimulating effect upon weeds that are certain to be troublesome in the turf. These suggestions for the use of lime are based on conclusive results from actual experiments, and not on theory. On fairways of Kentucky bluegrass there need be no hesitancy in using lime, because of its tendency to encourage white clover. There is no real evidence that it either benefits or deters the growth of white clover on average soils. There now appears to be much fallacy in the belief that the presence of certain plants indicates an acid condition of the soil. Possibly the presence of some plants does indicate soil acidity, but as a

*Reprint from *Golf Illustrated*, Mar., 1919.



Composting the Raw Peat Before Applying to the Fairway
(Through courtesy of Golf Illustrated.)

positive indicator of the lime requirement of soils, plants are not very dependable.

Many of the mistakes and fallacies in the use of fertilizers proper are due to a lack of knowledge regarding the real functions of fertilizers which are indeed much more complex than is commonly supposed. Their role in plant growth is not confined to furnishing nitrogen, phosphorus and potassium in forms available to the plant, but includes many other reactions. The purchaser of commercial fertilizers, however, must be guided very largely by the chemical composition of the goods offered and as a rule will find it profitable to purchase the kinds having the highest percentage of available nitrogen, phosphorus and potassium. The sellers of fertilizers frequently take advantage of the purchaser by writing their analyses in such a way as to convey a misleading impression of the actual quantities of the important fertilizing elements present. For example, the nitrogen content of a fertilizer is often expressed in terms of ammonia, which is about 20 per cent greater than the actual nitrogen content. This may be illustrated by the case of sodium nitrate, which has approximately 15 per cent nitrogen or 18 per cent ammonia. The phosphorus content of a fertilizer should be expressed in terms of phosphoric acid (P_2O_5 .) A study of the chemical terms used in expressing analyses would result in economy in the purchase and use of fertilizers.

Nitrogen fertilizers are the most important for turf grasses. Phosphatic fertilizers are also helpful to the growth of these grasses, but much less important than those carrying nitrogen, and the benefits of potassium-bearing fertilizers are seldom realized except when used on light, sandy soils. The money invested in fertilizers is frequently misspent because these points are not kept clearly in mind. There is a very common prejudice against the use on putting greens of fertilizers containing phosphoric acid and because of its stimulating effect on white clover. Phosphatic fertilizers doubtless benefit white clover, but the extreme prejudice which exists against them is not warranted. Bone meal is a very safe fertilizer to use on turf, as it does not scald the grass and is lasting in its effects. The mistake is frequently made of not applying it early enough in the season. When it is intended to benefit the grass in the spring it should be applied two or three weeks before active growth commences. It then has time to disintegrate and become available to the grass when it can be used most advantageously. Very little is lost by leaching when it is applied late in the winter.

The value of ammonium sulphate as a fertilizer to eradicate white clover or to depress its growth has been greatly exaggerated in the popular mind. Carefully conducted experiments to determine its efficacy fail to disclose any unusual properties as a white clover exterminator. Furthermore, as a source of quickly available nitrogen, it is not as desirable for fine turf grasses as nitrate of soda.

Much has been said of peat or muck as a humus material for use either as an organic substance to be mixed with the soil when putting greens are being constructed, or as a top dressing to be applied after the turf has developed. Some peats, even as they occur naturally, are very valuable for either purpose, but there are others that have a positively toxic effect on grass. Therefore it is unwise to use raw peat unless its qualities are known beforehand, and even then it is much safer to aerate, leach, and compost it before using, since the deposit in any peat bog is very likely to lack uniformity. Some commercial peats have been found to be so toxic as to kill seedling grass plants at a very early stage of their development. When used as a constituent of a germinating layer, such peats are particularly undesirable.

Rolling seems to have a peculiar fascination for some green-keepers, as they do it in many cases without regard to the kind of soil or its condition, and it is not putting the case too strongly to say that nearly as much harm as good has resulted from the use of the roller on our golf courses. The functions of rolling are to smooth out the irregularities in the turf and to compact the soil when needed, but it has no mysteriously stimulating effect on the growth of grass. Turf on stiff clay soils is easily injured by heavy rolling when the soil is wet. Reasonably heavy rolling in the spring to smooth the surface of the turf and to settle the soil after the frost action of winter is beneficial for fairways and putting greens on heavy as well as on light soils, but the use of a heavy roller on moist, clay soil after an early spring treatment has been given is of very questionable benefit. The indiscreet use of heavy auto mowers has damaged many heavy, clay courses. Less caution is necessary in the rolling of sandy soil courses, and the danger of over-compacting the surface soil on such courses is rather remote, therefore reasonably frequent and heavy rolling is more likely to be beneficial than otherwise on sandy soils.

There is a very general belief that mowing grass forces root development. This is clearly a fallacious notion. Clipping does not cause root development, but it does stimulate stooling or branching. Frequent clipping is often injurious to young grass plants, especially if it is done closely, but on old greens

frequent mowing is not usually harmful to the grass unless the mower is set so low as practically to crown the plants. Considerable judgment is required to regulate a mower properly.

NEW PROCESS FOR MAKING FUEL BRIQUETTES.

(Trade Commissioner Thermod O. Klath, Copenhagen,
April 11, 1919).

A new process has recently been invented in Denmark for the manufacture of fuel briquettes from peat and low grade native brown coal, combined with a binder consisting of pitch or coal tar. The briquettes are made by subjecting these materials to heavy pressure in a machine costing about 10,000 Crowns (\$2,680), with a capacity of 10 or 12 tons per day. The motive power is supplied by a 12 horsepower electric motor.

It is claimed by the inventor that the briquettes can be produced at a cost of about 46 Crowns per ton (\$12.33). This figure will be much less when the pitch used as the binding material becomes lower in price. The briquettes are said to give good satisfaction as fuel due to their low water content (about six per cent.), which is practically the same as ordinary imported coal.

An analysis of this new fuel furnished by the inventor shows the following: Carbon 67.35%; Hydrogen, 3.6%; ash, 18.05%; water 6.05%; nitrogen, 1.38%; sulphur 1.02%; and oxygen, 2.53%. It produces almost as much heat as the English coal imported into Denmark.

There is already a factory operated at Aalborg producing the briquettes, and it is planned to start factories at Copenhagen, Esbjerg, Aarhus, and at other points. The inventor has patented his process and machine in a number of European countries and has applied for a patent in the United States. It is said that the exclusive rights to its use in Schleswig have recently been sold for 100,000 Crowns (\$26,800).

It may be possible that some of the large peat areas in the United States could be made to produce a cheap fuel by the use of some such process.

U. S. GEOLOGICAL SURVEY ON PEAT STATISTICS.

Dear Editor:—I have just read with considerable surprise the criticism of the Geological Survey's statistics on the peat industry in 1917, that appeared on the first page of Vol. 12, No. 2, of the Journal of the American Peat Society. The article states that the Geological Survey's figures are misleading

and unreliable because they do not show in the table headings the moisture content of the peat.

If this statement had been made by one unfamiliar with the nature of peat and of the peat industry, it would be unworthy of notice, but as it appears in the technical journal of the American Peat Society it seems to me the article calls for the following comments:

Statistics of production are universally given in terms of the actual weight of the commodities in a commercial sense. In the case of coal this means the actual weight of the air-dried product at the mine and in the case of crude peat of the air-dried material either on the surface of the bog or in the stock pile. In other words the correct import of the figures is that the output of crude air-dried peat in the United States in 1917 was 97,363 short tons. The quantity of peat sold and used as an ingredient of commercial fertilizer and as a direct fertilizer was 92,263 short tons, and of stock food 5,100 tons. In other words these quantities of crude air-dried peat were produced and used for an ingredient of commercial fertilizer, for a direct fertilizer, or for stock food.

The statement that a considerable amount of wet peat is sold is in error. The author of the statement has confused air-dried peat with native peat in the bog. It is true that native peat in the bog contains from 75 to 90 per cent of water, but this is not a product of commerce. As soon as it is excavated evaporation begins and if it is exposed for even a short time the moisture content will be materially reduced. There are but one or two small producers in this country who sells peat containing moisture in excess of 30 per cent. Peat containing more moisture than this can not be economically moved.

So far as I am aware no statistics of production have ever been given on a theoretically dry basis. The purpose of mineral statistics is to show the output of commodities and other related industrial features as they enter the markets and no experienced statistician would express the production of peat in terms of theoretically dry material. This practice is proper in chemical determinations, but it would be improper in a statistical report.

The Geological Survey has been publishing data concerning the domestic peat industry since its beginning. In former years the work was in charge of Professor Charles A. Davis, whose statistical, geologic, and technical reports are highly regarded both in this country and abroad. The table headings used by Professor Davis in former years were followed in substance in Peat in 1917, and it is believed that statisticians as

well as practical peat operators have had no difficulty in interpreting the tables in that report.

When the subject of peat was assigned to me in 1916, the output was low and there was little public interest in peat in this country. By means of press bulletins and other reports, the interest of the public has been directed to peat as a raw material for many industries. Much work has been done by the Geological Survey and detailed reports are now in process of publication. Last year the output was more than double that in 1916. The Geological Survey is one of the few Federal bureaus that has helped the peat producers and directed attention to its occurrence, uses, and possibilities. In view of the large volume of work I have done upon the subject and of my earnest solicitation for the welfare of the peat industry, I feel somewhat disappointed that my report should be unjustifiably criticised in the official organ of that industry. If permissible I should be glad to have this letter published in the next edition of that journal.

Yours very truly,

Clarence C. Osbon,

In Charge of Peat Investigation.

Washington, D. C., July 11, 1919.

An Electric Bell For Opportunity

Don't make Opportunity knock.

Have a loud ringing electric bell ready to warn of her slightest touch at your front door.

In the shape of savings—War Savings Stamps—money in Bank.

Ready to take you whither she beckons.

Debts deafen one's ears to Opportunity—ready cash is her favorite telephone.

Begin to save—to-day—for the Sunny Opportunity she offers every one—*once*.



Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York, City.

Dear Sir:—

I, the undersigned, being interested in the development of our peat resources and in the welfare of the peat Society, beg to make application to membership in your Society, for which I enclose \$5.00 as annual dues.

Signed

Address

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Vol. XII

OCTOBER, 1919

No. 4

NOTE.

The publication of articles in the Journal of the American Peat Society is not an endorsement of the same by the Society or its officers. The American Peat Society is not responsible for the statements and opinions advanced by authors or correspondents. Written discussions on articles appearing in the Journal are invited. Correspondents and articles regarding peat and cognate subjects solicited.

EDITORIAL OFFICE.

Please note that the Editorial Offices are now changed to 1 Peace Street, New Brunswick, N. J., to which place all communications regarding the Journal should be addressed.

PROCEEDINGS OF THE 13th ANNUAL MEETING.

The Annual Meeting took place at Minneapolis, Minn., on Sept. 22nd, 23rd and 24th as arranged, with our President, Prof. Peter Christiansen, presiding. There were over 100 members and guests present and a successful and enthusiastic meeting was enjoyed.

Minutes of Business Meeting

Held in Minneapolis 9 to 11

A. M. September 24,

1919.

1. Prof. F. J. Alway was appointed secretary pro-tem.
2. Madison, Wisconsin was selected for place of meeting next year.
3. The following officers were elected for the ensuing year:
President
Professor H. C. Thompson, Cornell University, Ithaca, New York.
First Vice President
Professor A. C. Whitson, Agricultural Experiment Station, Madison, Wisconsin.
Second Vice President
Professor C. S. Robinson, Agriculture Experiment Station, East Lansing, Mich.
4. Voted, that the president be given power to increase the executive committee to nine (9) members exclusive of the officers, that in this connection active members be favorably considered and that the executive committee transact business by mail and telegraph as usual.
5. Voted, that the president appoint a membership committee and that this appointment of a membership committee be made a part of the by-laws if the present by-laws do not cover this appointment.
6. Voted, that as many members as possible write to their respective representatives in Congress stating that if the Federal Government considers it necessary to encourage the American Potash industry by act of congress this encouragement should be done by some means other than by imposing an import tax on foreign potash salts.
7. Voted, to endorse the plans of the Roosevelt Memorial Association.

Resolutions.

WHEREAS: the Roosevelt Memorial Association has

been formed by the friends of the late Colonel Theodore Roosevelt to honor his memory; and

WHEREAS, the Roosevelt Memorial Association aims to provide in accordance with the plans of the National Committee which shall include the erection of a suitable and adequate monumental memorial in Washington; and acquiring, development and maintenance of a park in the town of Oyster Bay which may ultimately, perhaps, include Sagamore Hill, to be preserved like Mt. Vernon and Mr. Lincoln's home at Springfield;

WHEREAS, the Roosevelt Memorial Association announces a National campaign for funds in the week of October 20th-27th; and

WHEREAS, the sum of five million dollars is to be raised through the subscriptions of millions of individuals;

Therefore, be it

RESOLVED, that THE AMERICAN PEAT SOCIETY recognizing his superlative Americanism and his inestimable services to our nation as citizen and statesman, hereby records its hearty endorsement of the plans of the Roosevelt Memorial Association and pledges its support to the National campaign to be conducted by the Association.

Peter Christianson, President.

F. J. Alway, Sec'y Pro-Tem.

Minneapolis, Minn., September 24, 1919.

The program carried out was as follows:-

**AMERICAN PEAT SOCIETY,
MINNEAPOLIS MEETING 1919.**

Headquarters—The West Hotel.

PROGRAM

Monday, September 22.

9:00 to 10:00 a. m.—Registration of Members.

10:00 to 10:30 a. m.—“General Consideration of Peat Problems.” By Peter Christianson, School of Mines, University of Minnesota.

10:30 to 11:00 a. m.—“Cooperation in Peat Investigations.” By Dean R. W. Thatcher, Dept. of Agriculture, University of Minnesota.

11:00 to 11:30 a. m.—“Agricultural Values of Indiana Peat and Necessary Fertilizers.” By S. E. Conner, Agricultural Experiment Station, Lafayette, Indiana.

11:30 to 12:00 a. m.—“Improvement of Wild Meadow and Tule Land.” By W. L. Powers, Agricultural Experiment Station, Corvallis, Oregon.

1:00 to 2:00 p. m.—“Vegetable Gardening on Eastern Muck Soil.” By Paul Work, College of Agriculture, Cornell University, Ithaca, N. Y.

2:00 to 3:00 p. m.—“Peat as Litter.” By Otto I. Bergh, North Central Experiment Station, Grand Rapids, Minnesota.

3:00 to 4:00 p. m.—“Marsh Soil Development in Wisconsin.” By A. C. Whitson, Agricultural Experiment Station, Madison, Wisconsin.

Tuesday, September 23.

9:00 to 10:00 a. m.—“Grasses and Clover for Peat Lands.” By A. C. Army, Dept. of Agriculture, University of Minnesota.

10:00 to 10:30 a. m.—“Toxic Substances in Peat Soils.” By C. C. Rost, Dept. of Agriculture, University of Minnesota.

10:30 to 11:00 a. m.—“The Fens Country of England.” By G. R. McDole, Dept. of Agriculture, University of Minnesota.

11:00 to 12:00 a. m.—“Minnesota’s Peat Experimental Fields.” By F. J. Alway, Dept. of Agriculture, University of Minnesota.

1:00 to 9:00 p. m.—Excursion by automobiles to Coon Creek Experimental Fields, returning via Crex Grass Meadows, Camp No. 1 where a wild duck dinner was served to about 85 guests by the Crex Company.

Wednesday, September 24.

9:00 to 11:00 a. m.—Business Meeting.

11:00 to 12:00 a. m.—“Logical Method of Utilizing Minnesota Peat.” By H. H. Hindshaw, Mineral Land Division, Minnesota State Auditor’s Department.

12:00 to 12:30 p. m.—Demonstration of Burning Powdered Peat, by F. E. Bryan, Hennepin Atomized Fuel Company, Minneapolis.

1:00 to 3:00 p. m.—“Michigan Muck Farm Management.” By Ezra Levin, Michigan Agricultural College, East Lansing, Michigan.

3:00 p. m.—“Iowa Peat Soils.”*—By W. H. Stevenson, Iowa State College, Ames, Iowa.

3:00 to 4:00 p. m.—Demonstration of Distilling Peat and Using Gas for Power Purposes by Straw Gas and Creosote Distilling Co., Minneapolis, Minnesota.

*Read by title only.

**Read by C. V. Ruzek, Agricultural Experiment Station, Corvallis, Oregon.

FINANCIAL REPORT FOR THE YEAR ENDED JUNE 30, 1919.

Receipts

Dues from Members.....	\$702.09	
Journals Sold	121.50	
Analyses and Report	30.00	
Advertisements	31.50	
	<hr/>	
Total Income	\$885.09	
Cash on Hand July 1, 1918.....	248.73	\$1133.82
	<hr/>	

Disbursements

Printing and mailing of Journal.

July 1918' Number	\$135.83	
October 1918 Number	132.26	
January 1919 Number	69.71	
April 1919 Number	95.32	\$ 433.12
	<hr/>	
Editor's Expense	96.06	
Postage Stamps	66.85	
Stationery	62.85	
Analyses	25.00	
Index to Vol. XI.	17.50	
Advertising	26.25	
Typewriting	9.75	
Misc. petty items	12.08	310.34
	<hr/>	
Total Disbursements	743.46	
Cash on hand July 1, 1919	390.36	1133.82
	<hr/>	

RESOLUTIONS ON THE NATIONAL FEED BILL.

On March 3rd last a National Feed Bill was introduced into the House by Representative Asbury F. Lever of South Carolina, Chairman of the Committee on Agriculture of the House. The bill authorized the Secretary of the Treasury to:—"Establish standards of classification of commercial feed, to regulate the sale and shipment thereof in Interstate and Foreign commerce, to prevent deception with reference thereto, and for other purposes."

Section seven of this bill states that:—"Commercial feed shall be deemed to be adulterated if it contained any humus, peat, saw dust, sphagnum moss or any added sand, soil, etc."

As soon as this matter came to the attention of our Executive Committee, through the courtesy of one of our members, a meeting was called and the matter thoroughly discussed. The Executive Committee, however, were unable to draw up resolutions at that time, as they did not have enough data on hand which would convince the members of the Committee of Agriculture or the Secretary of Agriculture himself of the injustice of this section. It was therefore decided to obtain enough data from Europe and parts of this Country where peat had been used in commercial stock food, and then to meet again for the purpose of drawing up resolutions. As the most important data on this subject could only be furnished from European sources it took several weeks before the Committee were able to get together and act on this subject and draw up the Resolutions which appear below.

It appears that the bill referred to in our Resolution died at the close of the last Session of Congress, but a new bill:—"To promote Agriculture by preventing the adulteration and misbranding of commercial feeds, and for other purposes.", was introduced in the House of Representatives by Gilbert N. Haugen of Iowa on August 8th.

Under Section four of this bill it states "That any commercial feed shall be deemed to be adulterated within the meaning of this act if it:—Contains any humus, peat, saw dust, Sphagnum moss, etc....."

However, our resolution fell into the right hands as the Committee on Agriculture has not been materially changed, and our Secretary has received replies from all parties to whom the Resolutions were sent, who show interest in this matter and will take the information, the American Peat Society has submitted to them, under consideration when the bill comes up before the Committee.

The American Peat Society would indeed appreciate it if our members would communicate with their respective Sena-

tors and Congressman on this subject, so that as wide a publicity as possible can be attained on the matter.

At a meeting of the Executive Committee of the AMERICAN PEAT SOCIETY held in New York, Friday, August 15, 1919, a discussion of the National Feed Bill, introduced in the House on March 3rd, by Mr. Lever, Chairman of the Committee on Agriculture of the House, took place and the following RESOLUTIONS were adopted:—

WHEREAS:—A bill has been introduced before Federal Congress, which contains in Section 7, words to the effect that will prohibit the use of Peat or Humus (in any form) in commercial stock food.

WHEREAS, Humus or Peat properly prepared have proven to be beneficial in commercial stock food.

WHEREAS, Properly prepared Humus or Peat, together with molasses, can be used as a means of fattening live stock, without any detrimental effect.

WHEREAS, Properly prepared Humus or Peat in commercial stock feed prevents colic in live stock.

WHEREAS, The introduction of properly prepared Humus or Peat in sweetened feeds has shown that same is assimilated by live stock.

WHEREAS, Properly prepared Humus or Peat has proven to be a corrective in live stock diseases.

WHEREAS, Properly prepared Humus or Peat has been used to a very large extent in Europe for over twenty years with beneficial results; and in this country for the past ten years, with a constant growing increase, which is prima facie evidence that Humus and Peat have merit when combined with sweetened feed, being thus known as commercial stock food.

WHEREAS, The means of increasing the meat supply of the country is urgent, therefore be it

RESOLVED THAT:—The use of properly prepared Peat and Humus be allowed to be used in the preparation of commercial stock food.

BE IT FURTHER RESOLVED THAT, Inasmuch as Humus and Peat have been used by the same feeders of stock in the same territory for the past ten years with such marked results of success;

THAT, before any detrimental legislation in the way of prohibiting the use of Peat or Humus in commercial stock food be enacted, The United States Department of Agriculture make a scientific feeding test, with or without the co-

operation of the American Peat Society, in the fattening of cattle and hogs with a commercial feed (i.e. a sweetened feed), containing properly prepared Humus or Peat, to definitely determine whether Humus and Peat has merit in such a feed as against prejudice, which is evidently the reason for proposed legislation to prohibit the use of Humus or Ueat in commercial stock food.

FURTHER BE IT RESOLVED THAT, Copy of a letter from Prof. P. V. Ewing, of the Texas Agricultural Experiment Station, under the date of June 20th, 1919, be appended to these Resolutions (Appendix 1).

FURTHER BE IT RESOLVED THAT, Figures and statements received through the courtesy of the British Board of Agriculture, relative to the use of Peat and Humus in cattle feed be appended to the Resolutions, (Appendix 2).

FURTHER BE IT RESOLVED THAT, A copy of these Resolutions be sent to the Secretary of Agriculture, to the Chairman of the Committee on Agriculture of the Senate and each member of such committee, to the Chairman of the Committee on Agriculture of the House, and each member of such committee and to the editor of the Journal of the American Peat Society for publication therein.

APPENDIX 1.

TEXAS AGRICULTURAL EXPERIMENT STATION

B. YOUNGBLODD, Director.

College Station, Texas

June 20th, 1919

P. V. Ewing, Animal Husbandman

Swine Investigations.

Mr. Herbert Philipp

Editor, American Peat Society Journal

Hackettstown, N. J.

Dear Sir:

Yours of June 12, received. In reply beg to state that I have done a small amount of experimental work in peat or humus feeding. These results have not been published officially. In general it was found that a small amount of humus seemed beneficial, just as a small amount of charcoal proved beneficial for swine. Under no circumstances should the amount be excessive, however, because experimental evidence tends to show that when fed in quantity, peat or humus may have a depressing effect on digestion.

In addition to the beneficial effects on the health of the hog, when fed in small amounts, say from two to five per cent, it was found that the mechanical influence of peat or humus in the case of certain commercial feeds, especially molasses feeds, was very desirable, as it prevented caking or hardening and loss from evaporation.

Very truly yours,

(Signed) P. V. EWING,

Animal Husbandman Swine Investigations.

APPENDIX 2.

STATEMENTS THROUGH COURTESY OF THE BRITISH
BOARD OF AGRICULTURE.

The Molassine Meal Company, Limited, of England, being the only large users of peat for the manufacture of feeding stuffs in the United Kingdom, state that they sold, before the war, in some years about 45,000 tons of commercial stock food, which contained about 25 per cent properly prepared peat.

IT IS FURTHER STATED THAT the best breeders in the United Kingdom have used such feed with success for the last eighteen years. It has been fed to horses, cows, sheep, pigs, poultry, and young calves after a few days from birth have had small quantities.

The consumption on the continent of Europe, for the last twenty years previous to the war, of commercial feed containing peat was from 112,000 to 224,000 short tons per annum.

U. S. PEAT INDUSTRY IN 1918.

The output of crude peat in the United States in 1918 far exceeded that of any preceding year and the general increase, which was stimulated by the war, was shared by practically all branches of the industry. Though extensively used as fuel in Europe and widely known in the United States as a potential source of heat and power, peat has been unable in most parts of the country to compete with coal and many peat operators have therefore directed their attention to the utilization of peat in agriculture with gratifying results.

Use of Peat in Agriculture.

Peat fertilizer was first marketed in commercial quantities in 1908, and stock-food peat in 1912, and though there is still some prejudice against the use of these products the agricultural branch of the peat industry has been successful and the quantity of fertilizer and stock-food peat annually produced is increasing. Large quantities of these products were made in 1918, but the most striking development of the year was the production of more peat fuel in the New England States than has been manufactured commercially in the entire United States in all preceding years. Almost equally striking was the widespread interest manifested in our peat resources which had heretofore been generally regarded as of doubtful value.

Use as Stable Litter, Packing Material, and Surgical Dressing.

Large quantities of peat or sphagnum moss were produced and utilized in this country in 1918 for stable litter, packing material, and surgical dressing, and several hundred thousand acres of peat soils were used for the growth of both general and truck crops. The peat litter was produced by the owners of small bogs for their own use, but the packing material was sold to florists for \$25 a ton. According to J. W. Hotson, of the American Red Cross, more than half a million peat moss pads were prepared in this country from October, 1917, to November 11, 1918, by the Northwest and Atlantic divisions of that organization. Most of the moss was gathered by volunteer labor from bogs in Washington, Oregon and Maine, and the pads were used in American military hospitals, both at home and abroad.

Statistics of Production in 1917 and 1918.

According to statistics compiled by C. C. Osbon, of the United States Geological Survey, Department of the Interior,

the quantity of crude peat produced in the United States in 1918 was 151,521 short tons, a quantity greater by 54,158 tons, or about 56 per cent, than the record output of 97,363 tons in 1917. Nearly all the producers of crude peat in this country refine their entire output, and it was therefore impossible to determine accurately the value of the raw material. However, the average price received for all refined products in 1918 was \$9.78 a ton, and the gross market value was \$1,049,493, a gain of \$2.49 in average price per ton, and of \$339,593, or about 48 per cent in gross market value compared with 1917.

The following table shows the quantity and value of peat products sold in the United States in 1917 and 1918.

PEAT PRODUCTS MANUFACTURED, IMPORTED, AND SOLD IN THE UNITED STATES IN 1917 AND 1918.

Kind of Product.	—Production.—		—Imports.—		—Sales.—	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
1917.						
Fertilizer and fertilizer ingredient	92,263	\$658,500	...	.....	92,263	\$658,500
Stock food	5,100	51,400	...	.....	5,100	51,400
Moss .....	.....	.....	506	\$4,966	506	4,966
	97,363	\$709,900	506	\$4,966	97,869	\$714,866
1918.						
Fertilizer and fertilizer ingredient.....	79,573	\$775,313	...	.....	79,573	\$775,313
Stock food	7,096	106,935	...	.....	7,096	106,935
Fuel	20,567	164,745	...	.....	20,567	164,745
Miscellaneous	25	2,500	...	.....	25	2,500
	107,261	\$1,049,493	...	.....	107,261	\$1,049,493

More Plants and a Good Market.

The total number of plants at which peat was commercially produced in 1918 was 25, an increase of 7 over the number operating in 1917. All the plants that operated in 1917 except 4 contributed to the output in 1918, besides 11 that were not operating in 1917. The plants known to be operating in 1918 were distributed as follows: New York and New Jersey, 4 each; Massachusetts, 3; Georgia, Illinois, Indiana, and California, 2 each; Maine, New Hampshire, Connecticut, Pennsylvania, North Carolina, and Florida, 1 each. Nearly all the producers reported that the demand for peat exceeded the supply, and some stated that on account of limited facilities they were unable to fill the orders of their regular customers.

Outlook is encouraging.

The notable increase in the output of peat in recent years especially in 1917 and 1918, is ascribed to the shortage and the high prices of nitrates and coal, to a nation-wide demand for increased food production that necessitated intensive agriculture, to a better understanding of the nature of peat, and to the application of bacteriology to crop cultivation. Though some of these causes of the increase in output were due to the war all of them will probably continue to affect the industry of this country, so that the demand for peat products will correspondingly increase and peat will maintain or even better the position it took in 1918 in the industrial activity and progress of the United States.

(U. S. Geological Survey Press Bulletin.)

NEW JERSEY PEAT INDUSTRY IN 1917.

The increased demand for domestic fertilizers because of the halt in imports since the beginning of the war has resulted in a rapid growth of the peat industry, in which New Jersey leads all other states. Discussing peat, a bulletin of the New Jersey Department of Conservation and Development gives the following information:

Native peat is a dark brown or black substance consisting chiefly of decayed vegetation and water.

While it is used very widely in Europe as a fuel, where the coal is scarce, it is used chiefly in this country for fertilizer or filler for commercial fertilizer because of its high nitrogen content. Peat is also used to a less degree as an antiseptic and in the manufacture of stock feed.

A large part of New Jersey's peat production is rendered more valuable as a fertilizer by chemical treatment and inoculation with bacteria, so as to increase the percentage of nitrates.

Last year the production in New Jersey amounted to 70,253 short tons, valued at \$360,862, while in 1917 the production was 42,361 short tons, valued at \$320,550, an increase of 27,892 short tons, and in value of \$40,312, according to figures published by the State Geologist.

PEAT IN CANADA IN 1917.

No shipments of peat were reported in 1917. In 1916 about 300 tons, valued at \$1,500, were shipped from a bog in Middlesex county, Ontario. In 1915 shipments were made from the Alfred bog, Prescott county, amounting to 300 tons, valued at \$1,095.

ANNUAL PRODUCTION OF PEAT.

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
1900	400	\$1,200	1909	60	\$ 240
1901	220	600	1910	841	2,604
1902	475	1,663	1911	1,463	3,817
1903	1,100	3,300	1912	700	2,900
1904	800	2,400	1913	2,600	10,100
1905	80	260	1914	685	2,470
1906	474	1,422	1915	300	1,050
1907	50	200	1916	300	1,500
1908	60	180	1917	Nil.	Nil.

PEAT SOILS OF MINNESOTA AND THEIR CULTIVATION***By. M. C. Cutting.**

The area of Minnesota is approximately fifty-two million acres. It has been estimated that seven million acres—nearly one-seventh of the total area of the state—are composed of peat soil. A small portion of this peat land is under cultivation; but by far the greater portion of it, especially the deeper layers, has never been touched by the plow. In the agricultural development of Minnesota, no problem is of greater concern than the subjugation of these vast areas of peat soil to the processes of stable farming. Fortunately, as this article will show, the means of that subjugation are now beginning to be learned.

Except for small sections in the south-eastern and north-western corners of the state, and a narrow strip along the western boundry, there is no portion of Minnesota that is entirely without peat bogs. According to E. K. Soper of the Oregon School of Mines, who made an exhaustive investigation of Minnesota peat a few years ago, the deposits vary in thickness all the way from a few inches to a maximum of about 60 feet. In the southern portion of the state the deposits are generally much shallower than in the north, the majority of bogs being less than five feet thick, with a maximum of about 18 feet. In the northern portion of the state, where by far the greater areas of peat are located, the average depth is seven to nine feet, but increases to 20 or 25 feet and even more in many places.

Minnesota Peat Mostly North.

Mr. Soper has said that at least 95 per cent of the peat in Minnesota lies north of the Twin Cities. Beltrami County alone has over a million acres of peat land, or 50 per cent of the county area. Other northern counties containing large deposits of peat are Koochiching, St. Louis, Itasca, Roseau, Aitkin, Crow Wing, Cass, Clearwater and Marshall.

Detailed soil surveys have been made in only six counties of Minnesota, and in five of these the deposits of peat were found to be as follows: Pennington, 66,000 acres; Anoka, 103,000 acres; Ramsey, 10,000 acres; Rice, 16,000 acres; Blue Earth, 7,000 acres. Practically all of the northern counties have large deposits of peat, and practically all of the central and southern counties have bogs of greater or less extent.

It must be clearly understood that these peat areas are not all of the same character and that they will not yield to the same treatment for agricultural purposes. As a matter of fact there are a dozen different kinds of peat in Minne-

*Reprint from *The Farmer*, 1919, Vol. XXXVII, No. 11.



sota, often differing radically in the same bog. Peat is formed during periods of thousands of years by the decay of vegetable matter in lakes and ponds, and in low places where the water level remains constantly at the surface. As these aquatic plants die and decompose, they form successive layers of decayed vegetable matter at the bottom, gradually building up until we have the peat deposits of today. According to the kind of plants, and the mineral agencies which have assisted in their decomposition, the peat will vary in character. It is the difference in peat bogs that has made their reclamation for agriculture so slow and seemingly so difficult to Minnesota farmers.

There are certain limiting factors, too, in the cultivation of peat soil, that should be considered as fundamental. The first and most important is drainage; another is climate; and still another is fertilization, according to the character of the peat. To these limiting factors should be added the cost of reclamation, especially where the land must be cleared as well as drained, and, in the northern part of the state, the lack of transportation facilities and the cost of marketing.

As practically all of the peat areas of the state are low and wet, they must first be drained. This is usually provided, and really can be provided, by large open ditches, often many miles in length.

The climatic limitation is one which affects the northern part of the state mainly, and is one which requires considerable study. A peculiar characteristic of peat soils is that they are especially subject to summer frosts, not because they occupy low places, but because of the rapid radiation of heat from the surface of the peat. These subnormal temperatures may be prevented by covering the peat with a few inches of sand, loam or clay. Observation indicates, too, that proper fertilization, producing a more vigorous growth of crops, helps to lessen radiation of heat and serves as a protection against summer frosts. Still another procedure is to devote peat soil to the production of crops that are highly resistant to frost, such as grasses and clovers, and market these crops in the form of dairy products or beef.

But the fertilization of Minnesota peat soils is the subject upon which the least is known, and it is the subject upon which we are first to gain enlightenment. Ordinarily, farmers with small bags are leaving them untouched, or using them as poor hay fields or still poorer pastures; and those who are trying to raise crops by the same methods employed on the ordinary soils, are doing so usually with very discouraging results. Even where the land is satisfactorily drained, natural

peat soil has proven to be very low in productivity; and the vast majority of these areas lie idle and undeveloped because of a want of knowledge of the proper method of cultivation and fertilization.

At last, however, the state of Minnesota has undertaken to unlock the secrets of production in peat soils. In 1917 the State Legislature appropriated \$6,000 a year for two years to be used by the State Experiment Station in making investigations of peat soils for agricultural purposes. These investigations are now under way, and in one section of the state some very striking results have been attained. This year the Legislature is asked for \$10,000 a year to continue and extend these investigations. A statement of the results already attained should be sufficient to decide whether or not that appropriation should be made.

Three Stations Established.

The appropriation of 1917 required that experiments should be conducted on three tracts of peat soil, not less than 10 acres nor more than 40 acres in each—one to be located in Beltrami or some county west of that, a second to be located in some northeastern county, and a third to be located in the southern half of the state. According to these provisions, in 1917 Dr. F. J. Alway of the Division of Soils, State Experiment Station, made his selections of experimental plots and proceeded to work.

For the northwestern section he selected a piece of land near Golden Valley, in Marshall County, representative of the open grass-covered bogs of that part of the state. For the northeastern section he selected a plot near Fens, in St. Louis County, representative of the tamarack-covered bogs. For the southern section he selected a piece near Coon Creek, in Anoka County, mostly open grass land, a few acres covered with tamarack, and the rest covered long ago but with no evidence of trees remaining until the old roots are discovered by the plow. Such land is representative of the peat in Central and Southern Minnesota.

At Fens and at Coon Creek the experimental tests last year were not so satisfactory as at Golden Valley, owing to difficulty in getting the soil prepared in the fall of 1917, and to other abnormal conditions in 1918 which disturbed the tests. However, tests were carried on at these two places, and they will be continued, and complete reports will be published. At Golden Valley, on the other hand, conditions for the preparation of the soil were most satisfactory, and a splendid season last year, remarkably free from summer frosts, lent every

encouragement to the conduct of comparative tests. Hence, the Golden Valley results are the first to be made public.

Before quoting these results, owners of peat land in other sections of the state should be warned that the success of a certain treatment at Golden Valley does not even mean that the same treatment will prove successful with them.

Dr. Alway urges farmers in Northwestern Minnesota not to accept these results as final, but first to try them in an experimental way. Six to 12 tons of stable manure per acre, or 200 to 400 pounds of acid phosphate, should be well worked into unburned peat soil before seeding, and the land heavily rolled. On burned peat the fertilizer is unnecessary, and rolling is apparently not beneficial unless a considerable depth of peat remains, except possibly in the case of hay crops. On either burned or unburned peat, good trial crops are spring rye, oats, barley, and a grass mixture of timothy and alsike clover.

As to the owners of peat land in other sections of the state, these experiments are not intended to apply, except possibly in a suggestive way. Singularly, all the knowledge obtainable as to the cultivation of peat soils in other lands indicates potash as the principal fertilizing element lacking. It may be that peat soils in other sections of Minnesota require potash or lime, or both, rather than phosphate. Owners of such soils may experiment with these three fertilizers to their hearts' content—or wait until the experiments at Fens and Coon Creek supply them with more definite information to work upon.

VALUE OF MINNESOTA PEAT.

By Henry H. Hindshaw.

(From St. Paul Pioneer Press, March 2, 1919.)

Farming is the greatest industry of the United States.

American farming has evolved under very different conditions than in the old world. We have been content to get a small yield per acre from a large acreage. The crowded countries have fewer acres and more men and the denser the population the greater has been the use of fertilizers. Japan, making use of every scrap of waste material at all suitable and the United States using virtually none except in the production of special crops.

The facts that America has had to feed the world and that it will have to continue to do so to a large extent, have forcibly brought to mind to all thinking people that the devel-

opment of American efficiency in crop production is as vital as in manufacturing. Machinery, drainage, irrigation and fertilizers, must make the American farm unit of labor at least twice that of any European country. Carrying out this development means an increased use of fertilizers. Our yield per acre of wheat, corn and potato crops could be doubled without great expense by proper culture and fertilization.

Nitrogen Immeasurably Better.

Let us consider what is needed. The great amount of talk spent on potash within the last few years has given us these results. First, the big agricultural chemical companies and dealers still claimed great virtue for potash, scarcity of which warranted higher prices.

Third year of the war, potash need not be used in such large proportions. Limestone was sometimes just as good, then eventually, there being no potash to sell, it was only needed on certain kinds of soil or for special crops.

What I wish to show is that nitrogen, of which we have millions of tons in Minnesota peat beds, is of immeasurably greater agricultural value than all the potash of Germany. The German potash salt beds have been considered one of the most valuable mineral deposits in the world. Before the war we were absolutely dependent on them for our supplies. Years of German advertising through the German Kali company made people believe that except for the loving kindness of the German government we would come to a sudden end for lack of potash. We got through without it and can continue to get along on American potash.

Nitrogen Exhausted First.

But with all the fuss about potash, compared with nitrogen it is a minor consideration.

What are fertilizers and why used?

There are ten essential elements of plant food: carbon, hydrogen and oxygen are derived from the air; phosphorus, potash and nitrogen are the elements sometimes deficient in soils and must be supplied from outside sources. These are the fertilizer elements.

Sulphur, lime, iron and magnesia always are present in the soil. There are five or six other not absolutely essential mineral elements, entering into plant growth but all common enough. All necessary plant food elements are abundant in normal virgin soils. Those first depleted by cropping are nitrogen, phosphorus and potash. Nitrogen is needed in great amounts and is the first element exhausted. Worn out soils

are almost invariably good soils from which the nitrogen has been nearly depleted by improper methods of farming.

However much in excess one element, phosphorus, potash or nitrogen may exist, it has no value without a proper ratio of the others. The element short its necessary amount is known as the limiting factor. In ordinary farming this is almost invariably nitrogen.

Is Complicated Process.

Soil improvement is a complicated process and free use should be made of the agricultural college in working towards this end, but I wish to point out that we have in Minnesota peat, one of the most valuable factors.

There are great stores of potash and phosphorus in the soil and subsoil, but nitrogen is not as the other soil constituents, derived primarily from the rocks, but must come from the air, indirectly and mostly through organic agencies.

Peat contains an average of about 2 per cent nitrogen. It is in such combined form as to be unavailable as plant food and raw peat has virtually no fertilizer value.

Coal usually carries about 1 per cent of nitrogen and our present supplies are from the distillation of coal for gas or for coke. The byproduct coke oven was introduced to this country to insure a constant supply of nitrogen in the form of ammonia for the manufacture of soda in which it is largely used.

Big Increase in U. S.

Ammonium sulphate, the form in which nitrogen is usually contained, is made by washing coal gas through diluted sulphuric acid and concentrating the liquid until the ammonium sulphate crystallizes out. The production of sulphate of ammonia in the United States increased from 19,500 tons in 1899 to 249,049 tons in 1915. Its consumption increased from 58,650 tons in 1903 to 232,000 tons in 1912. In 1911 Germany produced 400,000 metric tons. England 378,000, United States 27,000.

As to the agricultural value of nitrogen as sulphate of ammonia in 1911 there was used in pounds per acre:

	Sulphate	—Produced—	
		Wheat	Potatoes
	lbs.	lbs.	lbs.
Belgium	17.8	2,228	13,160
Germany	9.98	2,012	10,250
England	5.35	1,756	10,025
France	2.23	1,238	6,360
United States	1.34	900	5,400

From this table the deduction is plain that by using eighteen pounds of sulphate, costing 65 cents, Belgium raised two and one-half times the wheat and potatoes as the United States.

Says Results Enormous.

While all the credit cannot be due to this one factor, at the same time the results could be attained by no other means.

Minnesota has 5,800,000,000 tons of peat. The average nitrogen content is about 2 per cent. Through gasification about 150 lbs. of sulphate of ammonia can be recovered per ton of peat, making a total of 435,000,000 tons at \$60 per ton, \$26,000,000,000. This looks like the theoretical profit on raising chickens, the figures don't agree with practical results, but the actual results are enormous.

Sulphate of ammonia is now a byproduct of making coke and gas. With peat it will be the by-product of great power plants using gas fuel. Charcoal can also be another by-product or the main products may be considered the charcoal and sulphate and the power the by-product. The proportionate values of a ton of peat will roughly be:

Gas, 6,000 feet, at 3 cents.....	\$1.80
Sulphate, 150 pounds, at 3 cents.....	4.50
Charcoal, 750 pounds, at \$15 a ton.....	5.00

By complete gasification a much greater amount of power can be generated. This is not a new and startling innovation. By-product power plants are in operation in European countries. Some of these under very disadvantageous conditions. One Italian plant has a small peat deposit, five feet deep, with one foot of gravel in the middle, requiring a very expensive hand operation. This deposit would be laughed at in Minnesota, where we have individual bogs with thousands of acres twenty or more feet deep.

Predicts Great Results.

It is impossible to comprehend the big figures involved in Minnesota peat, but the values are comparable with the iron ores. A very few years ago even after their discovery, many great authorities could prove the ore to be valueless on account of its fine texture. The same kind of people can prove that peat is not usable, but fortunately they are a small minority.

One feature of the development which we should bear in mind is to conserve properly the interest of the state. Peat lands have been considered the least valuable, and great sums

have been spent in drainage, ditches and in other means of making them salable at any price.

If such sums were available for demonstration of practical methods of utilization, the great results which must come some time soon would arrive more quickly, and the harvest lying dormant, as our forests did for ages, can be systematically garnered, and with the values to the state cared for as it could not be in forest products.

The State Mines Department at Hibbing is looking into some of the larger features of the situation, and I hope to have something more to say, especially as to peat making available a great source of sulphuric acid in Minnesota, which is one of the links in the chain of recovery of sulphate of ammonia.

TONS OF PEAT FUEL AT DULUTH'S DOORS.

By H. W. Richardson.

(From Duluth Herald, Sept. 12, 1919.)

I would like to invite attention to the vast supply of fuel available at our very door—that of peat, the wonder-material of nature. Of the 13,000,000,000 tons of this fuel available in the United States, Minnesota has approximately 7,000,000,000 tons, and St. Louis and other northern counties have some of the largest and best deposits. Up to the beginning of the great war, with the appliances then in use, peat could not generally be transformed into merchantable fuel at costs low enough to compete with coal, but present prices of coal permit this and work along such lines has been greatly stimulated. Machines have been developed which can be placed on the bogs and produce a satisfactory grade of fuel in about one-half hour after the peat is taken from the bog, and at an estimated cost of \$6 to \$8 per ton delivered to the consumer. These machines vary in kind and capacity; one type will turn out fifty tons of peat fuel per day. Once the practicability and demand are shown literally thousands of such machines can be installed on the bogs. I have made some tests of prepared peat as fuel and with excellent results. It is clean to handle, there is practically no dust, and the resultant ash is small. In fact, the ashes can be applied to our soil with advantage because of potash content. According to the United States Bureau of Mines (Bulletin No. 16), the B. T. U.s are substantially the same in peat fuel as in the highest grades of anthracite. From the standpoint of chemical products—and there are a large number—enormous and very profitable in-

dustries are possible of development, and without impairment of fuel values. But that is still another story.

Anyhow, the present extremity affords opportunity to emancipate ourselves from wasteful methods and a threatened calamity, and enter upon a new economic era of the greatest advantage to the Northwest and this section in particular.

CALIFORNIA DELTA FARMS, INC.

The reclamation of the 40,000 acres of peat land is being cut into small farms by California Delta Farms, Inc., and the low price at which it is being sold are the result of a comprehensive vision and doing things on a big scale.

When Lee A. Philips, who has become one of the biggest developers of first-class land in California, looked over the situation in the Delta country fifteen miles below Stockton he saw that a marvelous project could be worked out.

He had already been interested in the reclamation of lands in this section and knew the proposition well.

He knew that the thousands of acres of tule-covered land spreading about him on various tracts would produce agricultural wealth that could not be surpassed in the world if leveled so no flood could ever reach them.

If this rich acreage could be made secure and sold at a low price a splendid development—a new glory for California—would result, he figured, and the soil would pass into the hands of prosperous American farmers. Roughly he estimated the land would be reclaimed and sold at \$350 or \$400 an acre, which would be a price at which smaller farmers could buy and build fortunes.

To sell at such a price, though, he knew, meant reclamation on a vast scale, with millions of money to do the work on the most substantial and enduring plan known. He organized California Delta Farms, Inc., and the project, after ten years work, has been completed.

The size of the project, though, has had the gratifying result of making it possible to start the first unit of 5,000 acres at \$250 an acre. The next unit is to be only \$275.

Arthur C. Parsons, agent for California Delta Farms, Inc., said, according to the San Francisco Examiner:—"The price of \$250 an acre, at which the first unit is going, is so low that neither the farmer who wants land to farm nor the man of other occupation who wants a cash yielding investment for his savings or surplus, can have any hesitancy in investing."

Not only the farmer, but the man following other lines,

can see at once what this land is. No matter who goes to look at it—farmer, business man, mechanic or any other—they all come back with the one statement: "It is everything that is claimed for it."

This peat land is so distinctive and shows so clearly its richness and tremendous productive force that anybody can see and understand at once its value.

Completion of this project, as outlined and carried out under the conception and plans of Philips, has not meant the mere building of levees and making it safe, although with just that the land would have been worth more than we are selling it for.

Philips, in his ambition for development, has not only reclaimed, but he has leveled and tilled, and the lands that we are selling are all under extensive cultivation right now with the wide variety of food crops for which the peat lands of the Delta are famous.

The variety and quantities of staple food crops that are being produced on these peat lands of the California Delta Farms, Inc., are perhaps but a fraction of what will be developed agriculturally on these acres.

What new and profitable crops the future may see, none of us now knows, but we know that many new money makers in an agricultural war are to come.

The corporation's good work in bringing 40,000 acres of rich soil under cultivation and cutting it up for public sale has won approval of prominent men.

Horticultural Commissioner Harry H. Ladd of San Joaquin county makes this statement:—

These 40,000 acres of peat land, with the irrigation, drainage and levees completed as they are, could be divided into 1,000 farms and make every single owner rich in a very few years.

County Assessor, John W. Moore, of San Joaquin, who owns a farm in the Delta Lands, states: "I have personally raised here in the Delta 45 sacks of barley per acre and 28 sacks of Lady Washington beans per acre. I have never raised less than 35 sacks of barley per acre. In 1916 I raised 85 bushel of shelled corn per acre, in 1917 96 per acre and last year 93 bushel per acre. One season, from a ten-acre field of barley, I raised 480 sacks, or 48 sacks per acre, which I sold at \$2.25 per hundred, or \$108 gross per acre.

My land has paid me 6 per cent. interest on a \$500 per acre valuation, and this "before the war prices."

"From 90 acres one season I harvested 2,700 sacks of

barley and then immediately planted the land to pink beans, which gave me 1,620 sacks."

Some of the purchases of the delta farms are reported as follows:

Purchaser.	Acres.	Cost.
M. J. Brandenstein, San Francisco, Cal. {		
W. A. Hoefgen, San Francisco, Cal. {	547	\$136,897
C. H. Hacker, San Francisco, Cal.	1,322	365,000
F. S. Goodman, Jackson, Cal.	100	27,500
J. Stark, Oakland, Cal.	100	27,500
H. Rose, Stratford, Cal.	51	14,000
C. B. Hubbard, Cal.	162	50,000
A. Carlson, San Francisco, Cal.	52	14,275
H. J. Jueneman, Livingstone.	192	48,000
N. Hansen	50	13,800
W. S. Alford, Ione, Cal.	100	27,500
G. A. Anderson, Oakland, Cal.	40	11,000
H. P. Williams	125	34,375
C. H. Morrison, Santa Ana, Cal.	21.47	5,021
G. Schwartz, Hanford, Cal.	72.84	20,031
L. N. Tappe, Los Angeles, Cal.	100	27,500
W. S. Alford, Amador, Cal.	100	27,500
Haverstick & Forskey, Amador, Cal.	68	18,700
E. S. Reed, Hanford, Cal.	160	44,000
W. Lacey, Los Angeles, Cal.	530	145,750
F. Beck, Compton, Cal.	583	160,390
C. B. Bonnestell, Ventura, Cal.	225	61,875
E. A. Starr, Cal.	169	46,475

PEAT SOILS IN IOWA.

There are considerable areas of peat soils in Iowa and special methods of treatment are necessary to reclaim them and make them productive. There are two classes of these peat soils, the shallow and the deep. The shallow peats are usually not over three feet in thickness and the treatments recommended must be understood to apply only to the shallow peats; they are not all applicable to the deep peats.

The needs of these shallow peats are for thorough drainage, cultivation and the growing of proper crops upon them. Drainage is the first and most important operation in their reclamation. Sufficient tile of ample size must be provided and proper outlets supplied, and it is usually advisable also to lay special drains to carry away flood waters and prevent the flooding of low-lying peat areas in times of heavy rainfall. The tile should be laid in the underlying subsoils, but not too deeply, as the heavy character of the subsoil may prevent the ready passage of water into the drains. It is often advisable to cover the tile at points a few rods apart with straw, gravel or cinders to permit the water to enter the tile readily.

Fall plowing is desirable for peat soils, as it opens them up during the winter and thus aids in the decay of the peat. Deep plowing is also of value, as it hastens the decomposition of the peat and also improves its physical and chemical condition by bringing up and mixing up with it some of the underlying clay which is rich in phosphorus and potassium, elements lacking in the peat itself. The Soils Section has not found the application of chemical fertilizers profitable on shallow Iowa peats, due probably to the presence in the sub-soil of those elements which are lacking in peat.

Corn and small grain crops as a rule do not do well on newly reclaimed peat. A mixture of timothy and alsike clover is the best crop to use on such soils. This may be used for hay or pasture. Many vegetables, such as onions, celery, tomatoes, potatoes, cabbage, etc., give good yields. By a few years of pasturing or growing vegetables, shallow Iowa peats may be put in a condition which will permit of the successful growth of corn and small grains and, in fact, after such reclamation the soils usually become highly productive. (Iowa Agri. Expt. Sta. Cir. No. 51.)

SOIL AERATION.

The importance of soil aeration in both agriculture and forestry is a factor that has only quite recently been recognized. This is rather surprising since the fact that fishes cannot live without the air dissolved in water has long been known and one would have thought that by analogy scientists would before long have come to the conclusion that there can be no life in animal or vegetable without access to oxygen. But now that it is known definitely we may expect it to be made the fulcrum on which all proposals for plant development will turn. We see from the "Agricultural Journal of India" that Mr. Howard records some valuable experiments to determine the effect on plants of aeration of the roots and of the deprivation of air. An illustration clearly shows the difference in development of both roots and plant between a specimen of barley grown under water culture aerated once a day and another aerated continuously. Natural aeration clearly depends on soil texture, as was proved by experiments made on such plants as sunflower, peas, wheat and cress with soil of five degrees texture, viz.—(1) soil in small lumps, loose; (2) soil fine, loose; (3) soil fine, firm below, with a loose surface; (4) soil fine, firm; (5) soil fine, hard. Here results varied visibly according to the degree of compactness, being best in the texture which most freely admitted air to the roots. That

is to say, within limits, pore space is of the highest importance, as it is this space that holds both the air and the water necessary to plant life; the water occurs in thin films round the soil particles, the air fills up the rest of the pore space. To quote Mr. Howard: "In the water films round the particles there is intense biological activity. New root-hairs are constantly being produced by the plant, which, for a time, absorb water and dissolved materials and then die. Various soil bacteria are occupied in the decomposition of organic matter. Both these activities involve the process of respiration. The working protoplasm in each case uses up oxygen and carbon dioxide is produced as a by-product. The soil atmosphere is therefore constantly being called upon to supply oxygen for respiration and receives fresh supplies of carbon dioxide. Efficient ventilation is clearly essential if the air in the pore spaces is to be kept fresh. Supplies of oxygen must pass into the soil from the atmosphere and at the same time the excess carbon dioxide in the pore spaces must diffuse out in the reverse direction. The pore spaces are the living rooms of a vast underground city the inhabitants of which require fresh air."

There is another important fact that has only recently been brought to light by investigations at Rothamsted. This is that rain water is a saturated solution of oxygen, and this oxygen is an important addition to the supply which functions in the pore spaces. It is now easy to understand the basis of a fact long known, viz., that rain water does more good to plants than water otherwise applied. Mr. Howard next considers the effect of irrigation. Briefly, each flooding adds to a crust which forms on the surface after each drying, and the thicker and firmer this crust grows the more effectively does it keep out air from the soil. It has, in fact, been shown experimentally that this surface film does bar the passage of air. The problem of cultivation thus becomes a determination of the relative amounts of air and of water to be applied to the root system: and Mr. Howard has proved, in the case of wheat, at least with the climate and soil of Quetta, that one watering results in a much larger yield than three, and he concludes that there the second and third waterings must have materially reduced soil aeration. He has accordingly introduced a system under which irrigation is given before sowing and subsequently all crusts formed by rain are broken up. Harvests under this method are often better than when six or seven waterings are given, they are about a month earlier and the character of both the wheat and straw is better. It must be noted, moreover, that similar results have been obtained

elsewhere as well. Soil aeration is, in fact, the basis of success in agriculture, it being found that special localities where the best of certain crops are invariably produced are localities where the soil is best aerated. This is the secret of the recent successes with laterite soils.

Let us turn next to the connection of soil aeration with forest growth as studied and recorded by Mr. R. S. Hole of the Forest Service. He experimented with sal seedlings grown in pots. Preliminary experiments made in 1909-10 showed that seedlings kept healthy in sand, but rapidly became unhealthy in loam or leaf mould when the soil in both cases was kept constantly moist. If, again, the pots containing the seedlings are glazed and the bottom holes are corked signs of unhealthiness soon become apparent. Or, reversing the process, if the bottom hole be left open but the surface earth be covered with leaves, the same result follows; but it may be noted that in the latter case when the medium in which the seedling is growing is sand no injury occurs. Besides these pot experiments and other experiments were made simultaneously in the forest itself. They showed that, whereas in the shade of the forest germination and seedling development during the rains is uniformly poor, even when the soil covering of dead leaves is removed and the soil dug, excellent seedling growth can be obtained if the trees are felled in narrow strips or small patches and the seed then sown in the clearings where the soil is exposed to the sun and air. Here again if pots containing sand are placed in the shade of the forest healthy seedlings can be grown in them, this being evidence that the deleterious factor is soil composition, and not deficient light. In fact an examination showed that the soil in shade invariably contained more water and organic matter than soil in the open. What happens is that for want of aeration in such soil the carbon dioxide rapidly increases and the dissolved oxygen content falls owing to bacterial activity. And the conclusion is that the injurious action on the roots of sal seedlings is associated with a very small oxygen and a high carbon dioxide supply, so that it seems probable that the most reliable indication of the conditions of aeration in the soil will be obtained by determining the quantity of oxygen and carbon dioxide existing in the soil, and that we may define a badly aerated soil as one in which there is a deficiency of oxygen and an excess of carbon dioxide. Soil aeration, in fact, depends on four things, viz.— (1) the amount of water in the soil; (2) the amount of organic matter in the soil; (3) the number and kind of soil organisms; (4) the rate at which currents of air, or water with oxygen in solution, penetrate into and percolate through the soil. Mr.

Hole tells us that in forestry there are broad methods of to some extent regulating soil aeration. Thus, the quantity of water, of soil organisms, and of organic matter can be regulated by varying the shade and the quantity of dead leaves added to the soil, and also by the controlled use of fire. Texture is also influenced by the amount of organic matter in the soil and also by such factors as the grazing of cattle both of which are capable of regulation. There are other regulating factors too with which forest officers are familiar. Here then we have the experience of the forester confirming and strengthening that of the agriculturist, and both clearly demonstrating that of the most important factor in cultural operations is one which has only recently come to light. Incidentally we learn that the principles which control life and health in the animal kingdom are identical with those that rule in the vegetable kingdom.—(Indian Engineering 1918, Vol. 64, p. 320.)

THE INDUSTRIAL PEAT PROBLEM IN IRELAND.

By George Fletcher.

"The problem of the utilization of peat for industrial purposes," writes George Fletcher, assistant secretary for technical instruction, in the Journal of Department of Agriculture and Technical Instruction, Ireland, "is one of perpetually recurring interest, and scientific men in many countries have turned their attention to search out a solution. This is not surprising in view of the fact that the amount of combustible matter in the world's peat deposits exceeds that of all the known coal fields. For Ireland the question is one of vital interest. Her coal deposits are small and relatively unimportant, while nearly one-seventh of the area of the country, i. e., over 2,750,000 acres, is covered with peat, much of which is of excellent quality. This represents a vast amount of potential energy awaiting only a practical means of utilizing it. It must not be forgotten that peat constitutes the only fuel for domestic purposes over the larger part of rural Ireland, but this does not affect the utilization of many large areas of bog as yet wholly undeveloped.

Defects as a Fuel.

"The defects of peat as a fuel are: (1) that it contains and retains a large amount of water; (2) compared with other fuels it has a low calorific value; and (3) it is extremely bulky, involving a high cost of carriage. Thus it is that most of the

schemes for peat utilization have been concerned with drying and compressing the material. Other schemes have sought to combine the preparation of a fuel from peat with the extraction of by-products. When one recalls the fact that by-products of the manufacture of coal gas, once regarded as useless, have come to rival gas itself in value, this aspect of the peat problem appears full of possibilities.

"A new vista of potentialities for peat has opened up in recent years. Just as the Nineteenth Century will always be associated with the development of the steam engine, culminating in the steam turbine, so will the Twentieth Century be able to claim the triumph of the internal combustion engine. The success of the gas engine has led to investigations which resulted in the many forms of producer gas plant, and there are now many thousands of installations of this method of producing power for mechanical purposes. Anthracite and coke are the most commonly used fuels. The possibility of utilizing peat was suggested by the Irish Department of Agriculture as far back as 1904. It is a noteworthy and encouraging fact that an installation at Portadown has been found to be entirely satisfactory, and to effect a considerable saving over anthracite. And this is the more remarkable as the by-products are not at present utilized. But these by-products are of considerable value, and two examples can be given where peat has been used in plants designed to recover the by-products.

Utilizing By-Products.

"The first of these is the power plant of an Italian company at Orentano. This plant, erected by the German Mond Gas Company, is situated on the edge of a bog. The area of the bog is about 1,482 acres. The portion of the bog operated by the company has an average depth of about five feet of good peat fuel. The bog has to be drained and the peat dried, part mechanically, part air dried. The average nitrogen content is about 1.04 per cent. This is recovered as ammonium sulphate, and the gas is used to drive two gas engines of 350 metric horse-power, each of which drives alternate current generators, there being a transmission line to Pontedera, 10 miles distant.

"The other installation referred to is the ammonium recovery power plant situated on the Schweger Moor, about 25 miles from Osnabruck. It is constructed to use peat containing upwards of 60 per cent of moisture—an important point as lengthening the season during which peat manufacturing operations could be carried on. The total power capacity is over 3,000 horse-power. The current transmitted at a tension

of 30,000 volts is distributed over an area of about 25 miles radius.

"It must be remembered that the reason more rapid progress has not been made in solving the problem in the United Kingdom is because coal is comparatively cheap and is more suitable for a producer gas plant owing to its greater heating power. But in Ireland in many parts coal is very dear, and the possibility of securing cheap power would be a stimulus to industrial development. Coming to the installation at Portadown, the plant supplies gas to two engines of 120 B. H. P. each and to one of 150 B. H. P. It is stated that under working conditions, with peat at 5s. a ton, power can be obtained at the rate of one-sixteenth of a penny per horse-power hour. The following statement as to the comparative cost of running the factory on coal and on peat, was given by the manager of the factory in 1912:

Cost of Running on Coal Per Week

8½ tons of anthracite @ 35s.....	£14 17s. 6d.
19 tons of steam coal @ 17s.....	£16 3s. 0d.
	<hr/>
	£31 0s. 0d.

Cost of Running on Peat Per Week

Say up to 50 tons of peat @ 6s.....	£15 0s. 0d.
	<hr/>
Weekly saving	£16 0s. 6d.

"Allowing for 15s. for extra labor, the weekly saving figures out at £15 5s. 6d.

Considerable Economy Effected.

"It is certainly encouraging to be able to record that the experiment has given complete satisfaction, that it has resulted in a considerable economy, and that an extension of it is in contemplation. With regard to by-products, the gas before passing to the engine must be purified, but the substances removed are valuable, although the by-products of a small plant would not justify treatment. There is nitrogen, which can be recovered as ammonium sulphate, and there is peat ash and peat tar, containing valuable constituents.

"It is not unreasonable to assume that with an extension of this method of utilizing peat, it would be possible to deal in a profitable manner with the by-products which would thus be produced in a sufficient quantity to allow of their being dealt with in chemical works. We should in this way not only establish an additional industry, but this method of obtaining

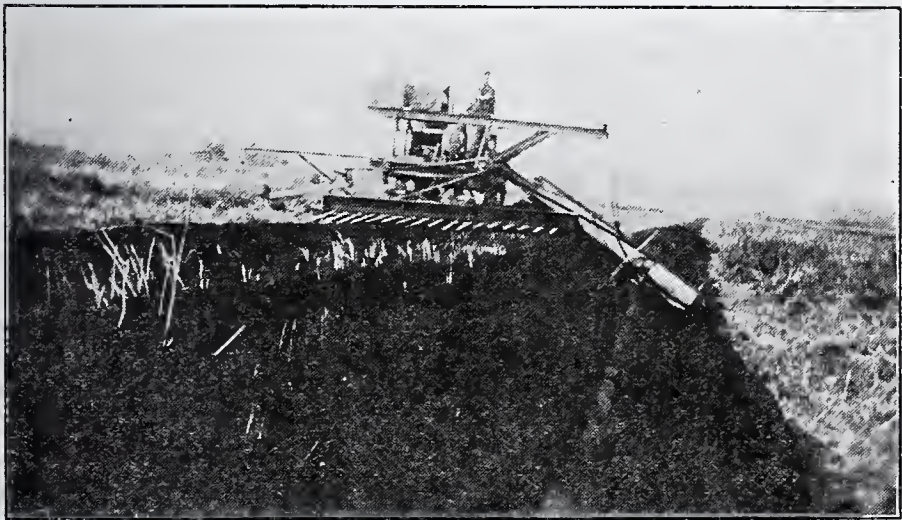
power from peat would be rendered still more profitable. It may be added that in the neighborhood of the bog from which this peat is obtained, near Maghery, is that worked by the Irish Peat Development Company, which manufactures peat litter and also peat dust, in which an export trade is done.

"The conditions at Portadown are favorable, in view of the neighborhood of the peat bog to the weaving factory, and it is undoubtedly of great advantage to have water carriage from the bog to the factory. But there are many places in Ireland where corresponding advantages could be availed of. Where a sufficient demand for power exists, it appears certain that instead of carrying the bulky peat either by road or water, it would be advisable to install a producer plant on the bog itself and to convert the mechanical power into electricity, and transmit the energy at high pressure to the point where it is required."

GARNETT PEAT EXCAVATOR.

A Garnett Peat Excavator is in daily operation on the peat deposit of the American Peat Products at Morrison, Ill.

The excavator is giving, according to reports, universal satisfaction, and is producing nearly four tons of dry fertilizer filler per hour.



The above illustrations show the Garnett excavator in operation, and the bank cut by the machine.

USE OF PEAT FUEL ON SWEDISH RAILWAYS.

Coal has been almost unobtainable, and substitutes produced in the country have been pressed into use. Many railroads resorted to the wood-firing without any alteration to the locomotive other than the removal of the air inlet valve on the fire door. Some lines have used 34 per cent. birch mixed with 66 per cent. of air-dried peat briquets, but such fuels have the disadvantage of emitting the large quantities of sparks. Experiments made with mixtures of coal and peat showed that the addition of 50 per cent of peat decreased the pull on the draw-bar, and they could only be used for trains with a speed not exceeding 31 miles per hour. By the "Ekelund" system of using powdered peat, introduced in 1890, the calorific value is used to better advantage than is possible with briquets. The first trials were not altogether satisfactory, but the Swedish Government took the matter up in 1916 and voted £72,000 (\$360,000) for a peat-powder factory, to produce 20,000 tons per annum. A number of locomotives are now using peat powder as fuel. The analysis of the powder is:—Moisture 16.16 per cent., ash 4.55 per cent., sulphur 0.18 per cent., combustible matter 79.11 per cent. The calorific value, exclusive of moisture, is 10,040 B. T. U. per lb., but as fired gives only 7,780 B. T. U. The cost before the war was about 9s. 6d. (\$2.00) per ton, at present it is nearly 25s. (\$5.00). It is estimated that it will not be economical to use peat powder for locomotives when coal can be purchased at 55s. 6d. (\$11.00) per ton.

(Teknisk Tidskrift, Feb. 1, 1919.)

GAS FROM PEAT.

E. Ott. (Swiss Gas Association.)

Owing to their comparatively high oxygen content and low carbon content, wood and peat, when subjected to destructive distillation, yield gas containing a high proportion of carbon dioxide, and consequently of low calorific value. The carbon dioxide content of the gas may be reduced by passage of the gas through dry lime. The plan for enriching the crude gas by addition of 1-20th of its volume of acetylene is also practicable, and a combination of both methods, entailing enrichment of gas with acetylene and removal of some of the carbon dioxide by the lime produced from the carbide, is suggested. When using wood the best results are obtained by high temperature distillation in retorts charged to not more than half their capacity; the acetic acid evolved is then de-

composed by the incandescent carbon. The difficulties introduced by the acid nature of the condensation products from wood may be reduced by neutralizing them with ammonia in the hydraulic main, or by distilling peat or coal along with the wood. The tars yielded by wood and peat are very hygroscopic. The solid residue from wood distillation contains from 2 to 6 per cent., and that from the peat from 6 to 50 per cent., of ash. Both solid residues absorb about 30 per cent. of water and hence should not be quenched with water.—(Gas Jour. 1919, Vol. 146, p. 83.)

DEVELOPMENTS OF PEAT FUEL INDUSTRY IN EUROPE

The working of peat as a substitute for coal is extending greatly in many countries, and notably in Austria, where a limited company with a capital of one million kroner has recently been formed to exploit the peat deposits at Salzburg and to work up the by-products. Peat from 2,000 localities in Hungary has been investigated, and the calorific values were found to range from 1,100 to 4,800 calories (4,400-17,200 B. T. U.). In Switzerland, where it is hoped that peat may be used for 18 per cent. of the yearly requirements of fuel, the Peat Association founded in 1917 has obtained a loan of 5 million francs from the Federal Council. English coal has been replaced in Sweden by wood and by peat, of which 120,000 tons was dug in 1916. The yearly output may be raised in the future to 400,000 tons, which would correspond in calorific value to 180,000 tons of coal. In Denmark the output of air-dried peat was 22,000 tons in 1916 and 56,000 tons in 1918. Trials in Denmark of mixtures containing peat as fuel for locomotives are said to have given favorable results. The investigation and development of the extensive Irish deposits is backward although the yearly consumption of peat in Ireland is at least 5 1-2 million tons.

USE OF PEAT AT ODENSE, DENMARK.

In 1918 peat established its place as a fuel more firmly than ever. It is used now by nearly all the industries, by the private railroads, and in country districts where it is practically the only fuel. Twelve million peat bricks were taken from Odense's marshes in 1918. Of these about one-third were used by the city and the rest by private families. The electrical works of the town of Svendborg have successfully used peat gas instead of petroleum. As a locomotive fuel it

proved to have some disadvantages, requiring a large boiler and giving off many sparks.

Peat producers have complained that the Government's maximal price on this article has made its manufacture difficult. There has been a lack of fuel oil for the peat machines, and other costs of production have increased. The result has been a number of failures, and the production will undoubtedly fall off in 1919, especially with the increased import of coal. However, the quality of peat has been greatly improved during the past four years, and more has been learned of its possibilities. It will, undoubtedly figure much more than previously as an economic factor here. Leading peat producers say that their greatest need is for a machine which can press the water from the peat immediately, so that the cutting of this material can be continued during the whole year. Such a machine would at once come into use all over Denmark.—(Commerce Report.)

NEW PEAT BRIQUET IN DENMARK.

A company has been formed for the manufacture of a new kind of briquet which has been patented in Scandinavia, Finland, and Germany. The briquet is made of peat dust mixed with brown coal, from which the water is evaporated, so that only 6 1-2 per cent of water is left in the finished product; it weighs half a kilo (1.1 pounds) and has 6,456 calories, as against 7,000 in coal, but the price will be only 60 per cent of that of coal. When the new factory is built, the production will be 8 tons per day.—(Consular Report.)

DEFINITION OF PEAT.

In a short discussion on the formation of peat, in the Pahasapa Quarterly, H. W. Talbot defines peat in the following words:—"Peat is partly decomposed and disintegrated vegetable matter that has in one way or another accumulated in areas of poor drainage where chemical changes, incident to ordinary atmospheric conditions have been retarded or suspended."

THE USE OF PEAT IN STEAM GENERATORS AND IN GAS PRODUCERS.

When peat is employed for the heating of boilers, the grate-bar spacing is less than that required for coal. The

distance between grate-bars depends upon the grade of peat used and varies between 8 and 20 mm. The average height of the bed of peat above the grate varies between 75 and 250 mm. In Sweden 1 kilogram of peat has evaporated, in a tubular boiler, 4.32 kilograms of vapor at 6.7 atmospheres pressure, whereas with coal, 7.44 kilogram of vapor are obtained under the same conditions. In other words, one unit of coal is equivalent to 1.72 units of peat. Locomotives require about twice as much peat as coal, by weight, and two fireman are required when peat is used. Inclined grates have been designed to handle peat and may be made automatic. The use of peat in the so-called semi-gas producers has been generally successful and special apparatus has been designed to burn powdered peat. There are several types of producers designed to handle peat among which are: the G. Korting, G. Luther and Ziegler, which are in use in Germany and Sweden, the Mond, and Limm in use in England and Italy, and the Riche and Allegre et Fabre, used in France. Several details of these types are given. (*Rev. chim. ind.* 1918, Vol. 27, p. 188).

GERMAN FUEL WEALTH.

Prof. Bergschlag lecturing on Germany's mineral wealth and her dependence on foreign minerals, said that Germany possessed 140 billion tons of coal, and 13.9 billion cubic meters of lignite. Prussia alone possesses two million hectares (5 million acres) of peat land, which represents sufficient power to meet industrial requirements for 750 years.

THE AMERICAN MINING CONGRESS.

The twenty-second Annual Convention of the American Mining Congress will take place at St. Louis, Mo., from Nov. 17th to Nov. 22nd, 1919. The Congress is composed of the producers of the basic raw materials of the nation. The sessions will be dedicated to the consideration of the readjustment of business, with the idea of bringing out various schemes and suggestions acceptable alike to capital and labor. Details of the convention can be obtained from the Convention Headquarters at Planters Hotel, St. Louis, Mo.

NATIONAL DRAINAGE CONGRESS.

The Eight Annual Meeting of the National Congress will take place in St. Louis, Mo. on November 11th, 12th and 13th at The Planter's Hotel.

The members of the American Peat Society are cordially invited to attend and partake in its deliberations.

As The National Drainage Congress is concerned with the development of our country, it is of undoubted interest to our members. Full particulars can be obtained from John A. Fox, Director, 38 South Dearborn St., Chicago, Ill.

POSSIBILITIES OF IRISH PEAT BOGS.

Colonel Warburton, late of the Royal Engineers, in an interesting letter to The Irish Times, deplores the apathy of the Irish in exploiting the vast power lying idle and unused in their peat bogs. He says it has been known since 1900 that peat can be employed for all purposes for which coal is used. It is always cheaper, and is now one-third the price of coal. He quotes the experience of Sweden, and that of Mr. Robb at Portadown, who tried peat gas as a substitute for anthracite coal at 32 s. 6d. per ton, and was able to save £400 a year in fuel. He also quotes Mr. Tatlow, who said at Cork in 1902: "When one thinks of the enormous amount of energy involved in this undertaking, and rendered necessary in grappling with difficulties which do not exist in Ireland, one is amazed and dejected to think of what they have done, and what Ireland has left undone."

Colonel Warburton says, that only in one or two cases, notably from Lord MacDonnell and Mr. Ginnell, M. P., has he received any encouragement concerning all the articles and letters he has written on the subject. He predicts that unless the Irish peat growths are successfully treated as in Denmark, Norway, Sweden, Germany, Russia, and Canada, the few industries remaining to Ireland will perish. Those who may think that the rise in price of coal is merely temporary, are living in a fool's paradise; everything is in favor of the future of peat, and Sir Richard Sankey has rightly described the peat bogs of Ireland as the true gold mines of the country.

PEAT FIBRE IN GERMANY DURING THE WAR.

Peat fibre belongs to the most interesting discoveries the field of substitute textile raw stuffs. This cannot, however, be practically used without mixture with other kind of fibre. A mixture of 50 per cent peat fibre and 50 per cent wool gives, according to the opinion of German experts, a very strong and durable material that looks extremely well and is excellent for men's clothing. The valuable qualities of peat fibre, however, are limited by the difficulties in pro-

curing the peat. Only the younger moss turf called "Grantorf," contains some 8 per cent of the "curls" which can be employed in spinning. The black peat (used for burning) cannot be employed. The production from about 5,000,000 double hundred weight of peat amounts to about 100,000 double hundred weight of fibre, in other words a very small amount, when the labor and the actual yield are both taken into account.

REPORT OF PEAT FIRES.

A peat bog on the outskirts of Chicago, near Highlands, has been burning for some considerable period and started to burn either spontaneously or through ignition from a locomotive spark. A circular ditch has been dug in an effort to arrest the fire, which covers several acres.

The Skokie swamp, north of Chicago, between Pine and Scott Streets, Winnetka has had fires, each year, since several years. The fires are attributed to careless hunters and tramps.

Peat fires caused considerable damage, this year, in the vicinity of Aitkin, Minn.

P. W. Swedberg, Moose Lake forest ranger, reported to the state forester that one road is completely burned out and a bridge destroyed.

Peat bog fires in the vicinity of War road in Northern Minnesota, are causing state forest rangers considerable uneasiness.

W. T. Cox, state forester, has received reports from his agents at Warroad that the fires are "slow burning" but persistent. The state forester has authorized the expenditure of \$300 by the district ranger for trenches to prevent further spread of the fires.

Mr. Cox is preparing a comprehensive plan for preventing serious forest fires in the future. This plan will be submitted to Gov. Burnquist upon the latter's return from the west Aug. 25, and will, it is expected, be transmitted to the legislature which will meet in special session Sept. 8.

The state forester said there was nothing new in the proposed plan except to urge sufficient funds to permit the employment of a larger force of regular men to cover the extensive territory embraced within Minnesota's forest area.

Whether gases, perfected in the war time experiments, can be used successfully to smother smouldering fires in

Northern Minnesota peat bogs may be determined by agents of the United States Bureau of Mines who have conferred with W. T. Cox, state forester, following the latter's inquiries on the problem. An investigation of conditions will be made in various districts and then effective methods of fighting the peat fires will be attempted. B. O. Pickard, Houghton, Mich., and J. E. Fleichut, Minneapolis, district representative of the federal bureau were assigned to make the investigation and will accompany Mr. Cox to Northern Minnesota.

Peat fires are the most difficult to entirely extinguish and are blamed for neavy annual losses and with causing numerous forest fires in the swampy sections of the state.

A ten year old boy broke through the peat deposit, along the banks of the Cloville River, at Chewelah, Wash., which was burning below the surface. The boy was burned to the hips and is reported to be recovering.

AN ELECTRIC MACHINE FOR PEAT EXCAVATION.

The efficient digging out of peat practically necessitates some form of excavating machinery, and it is interesting to observe that, according to "De Ingenieur," an electrically driven appliance of this kind has been in use in Holland for over 20 years. It consists of a strong frame supporting several vertical bars terminating in steel knives, and also buckets, into which the peat, when cut, is deposited. The machine is driven by an electric motor. It is possible to cut 1,100 cubic yards of peat per day of 10 hours, which is equivalent to about 350 tons of dry peat. The machine can be propelled forward on rails laid on the surface of the peat, or, when the water-level is near to the surface, on the deck of a raft.

CULTURAL EXPERIMENTS ON MOOR LANDS.

H. von Feilitzen.

The experiments described in this report were carried out in 1915 by the Swedish Moor Culture Association at Flahult and Torestorp in Jonkoping. An increase in yield of hay, in a 5-year test was secured by mixing sand with the surface layer of an imperfectly decomposed peat soil. The application of the sand paid for itself with the 3rd cutting. Shallow bog soil when mixed or covered with sand also gave favorable results in growth of different crops as compared with the un-

treated soils. With some crops the sand-covered plats gave best results, and the sand-mixed plats with others. Owing to the high nitrogen content of the moor soils the use of nitrogenous fertilizers on these soils was in general without result. Of the three phosphorous carriers, Thomas slag gave the best result, with superphosphate second and bone metal third. Early seeding as compared with late seeding gave better returns with such crops as turnips, oats, barley and potatoes. Leguminous crops grown for green fodder were not influenced much by late seeding. Results are given of variety tests made on peat soils with such crops as oats, barley, field peas, potatoes, turnips, carrots and different grass mixtures. (Svenska Mosekulturfor Tidskr, 1917, Vol. 31, p-16.)

DETERMINATION OF TAR VAPOR IN PRODUCER GAS.

A. Zschimmer.

The author uses an apparatus based on the same principle as that of Gwiggner (Chem.-Zeit., 1912, 461), in which the gas after leaving the filter is chilled to separate tar oils. The filter-tube is packed with cotton-wool and asbestos, or for higher temperatures with glass wool and asbestos, and after being weighed is introduced into the gas tube. The outlet of the filter is connected with a cooling-tube, which is suspended in ice-water, and which has plugs of cotton-wool in its inlet and outlet tubes. As a rule the gas is passed through the cooling tube for about 12 hours, the filter tube being changed every two hours. At the end of the given time the contents of the cooling-tube are transferred to a stoppered flask, and the cooling-tube rinsed with freshly distilled ether in the case of lignite gas or with benzene in the case of coal gas. The filter-tube is also washed out with the appropriate solvent, the solutions dehydrated by means of freshly ignited sodium sulphate, filtered through cotton-wool and sodium sulphate, evaporated at as low a temperature as possible, and the residue dried and weighed. The filter-tube containing gas-black and ash is dried by means of a current of hot air, and weighed. It still contains particles of tar, which must be washed out with hot benzene or toluene when a separate determination of gas-black and ash is required. For a simultaneous determination of water vapor in the gas two calcium chloride tubes are inserted between the filter tubes and cooling-tube, and the whole apparatus weighed before and after the passage of the air. The following results were obtained with typical samples of producer gas:

Combustible	Water %	Gas at 0° C. and 760 mm. litres	Tar and ash in filter grms.	Tar oils in cooling tube grms.	Increase in yield of tar by tar oils %
Peat	16.5	196	7.754	0.639	8.24
Peat	33.3	303	6.948	1.423	20.4
Lignite	34.7	87	2.121	0.145	6.84
Brown coal briquet.....	14.2	483	11.700	0.328	2.8
Brown coal	51.7	649	7.000	2.603	37.1

(J. Gasbeleucht, 1919, Vol. 62, p. 53.)

C. A. WILLMARTH COMPANY.

The C. A. Willmarth Company have moved their office from Detroit to Chelsea, Mich., where they have nearly completed the erection of a peat plant with their latest machinery for making fuel. Interested parties can visit them at this point and see the plant in operation.

PEAT PRODUCTS AND MACHINERY COMPANY.

Under the laws of the state of Delaware, a charter of incorporation was granted to the Peat Products and Machinery Co. for the manufacture of fuel products and machinery. The company is capitalized for \$25,000 and its incorporators are T. L. Croteau, P. B. Drew and C. L. Rimlinger of Wilmington, Del.

E. G. Hoff, of 1160 East Jefferson Avenue, Detroit, is trying to interest Michigan capitalists in the development of the **peat manufacturing industry**, which appears to hold out promises of good dividends. People who have made a study of fuel problems in Michigan have often wondered why financiers have not invested money in the peat business, especially since the source of supply of raw material is so close at hand. It is estimated that from the bogs of the upper and lower peninsula more than 300,000,000 tons of peat can be turned out and sold at prices a little less than those brought by hard coal.

It is estimated that one-seventh of the acreage of Michigan consists of peat bogs of an average depth of 15 feet. Within a radius of 75 miles of Detroit there is a peat acreage of about 20,000 acres. It is said that a working capital of \$25,000 would be sufficient to get enough raw peat out to manufacture 3,000 tons a month, and with an investment of this:

amount the first quantity shipment of finished fuel could be on the market in a month or six weeks.

THE PEAT PRODUCTS COMPANY OF AMERICA.

The Peat Products Company of America, a Wisconsin corporation with headquarters in Milwaukee, have applied to Minnesota officials for rights to experiment with a patented chemical process for the conversion of peat into fuel in deposits on state-owned lands.

Having heard estimates that peat deposits in Minnesota represent half of the total in the United States and if convertible into fuel at \$2 a ton would represent a value of more than \$75,000,000,000, Governor Burnquist said that the legal and other phases of the proposition would be investigated.

Carl W. Cobb, president, and James Gibbons, vice president and engineer of the Milwaukee organization, said they planned later to confer with J. A. O. Preus, state auditor, who is expected to return soon from Cleveland.

Fuel possibilities in the vast beds of peat over the northern part of the state of late have claimed special consideration from state officials, who announce that proposals for development will be investigated. The subject is rated of great importance because of the close proximity of the peat deposits to the iron mines and the possibilities for opening big smelters and refining plants near the mines and shipping pig iron instead of ore in the event that cheap fuel supply is made available.

Officers of the Milwaukee company asserted that a chemical process for converting peat into fuel was demonstrated a success by a machine operated last October at Sax, although the unit was destroyed in the Moose Lake Forest fire the second day of operation. They exhibited samples of peat fuel turned out by that machine and also in laboratory experiments. A second machine of forty tons capacity, they announced, is being built near Duluth and will be finished this year. It is said to change the wet peat bog into inflammable form in less than twenty minutes.

Permission to conduct experiments in peat deposits on state lands is sought, the officers said, to determine the effect of various chemicals on peat from different states.

ROWLAND COMPANY IN RECEIVER'S HANDS.

application made at Trenton on March 22nd, Judge
the United States District Court, adjudged as

bankrupt the Rowland Company, of Netcong, a peat concern. The court named as receiver in bankruptcy, Joshua R. Salmon, of Morristown, and fixed the bond at \$2,000. This action by the Federal Court supersedes a rule to show cause why a receiver for the company should not be appointed, which rule was issued by Vice-Chancellor Lewis.

The application for the bankruptcy was made by Elmer King, counsel for James G. Marcum, of Netcong, who was charged in the Chancery proceedings with mismanagement of the company.

Swiss Peat Syndicate.

A syndicate proposes at an early date to ask the federal council for a \$1,000,000 loan for the development of the peat industry in Switzerland. The extraction of peat will be undertaken on a large scale, it being planned to work 24 peat fields.

Sweden's Peat Resources.

Sweden has areas of peat deposits that are estimated to cover nearly 9,900,000 acres.

Lithuania Peat Deposits.

Lithuania, the republic asking for recognition of its independence, is rich in peat and the deposits are large and numerous. The inhabitants have used peat as a fuel for a long time. It represents a source of fuel and power which will come to be utilized more and more in future industry, its by-products being very valuable.

COAL, PEAT AND OIL, LTD., OF LONDON.

The Statutory meeting of this company was held last May in London, J. R. Tattersall presiding.

The chairman said that 300,000 shares of 2s (.50) each, 1s 9d. (.43) paid, which were offered to the shareholders in the Peat-Coke and Oil Syndicate, Ltd., 295,590 shares has been claimed by the shareholders, and the balance had since been sold by the liquidators, according to the terms of the agreement. In addition, 2,382 shares of 2s (.50) each had been allotted as directors' qualification and for signatories' shares, etc., incidental to the formation of the company. He could confidently say that he and his co-directors were abso-

lutely certain in their own minds, from the tests made and reports of analyses, that the company had got an exceedingly good thing, and he wanted the shareholders to bear in mind the very vital fact that one firm alone would take over the whole of the production in one particular branch of the undertaking. The board were quite cognizant of inquiries that were being made by other houses dealing in similar commodities as to the value of this company's method of producing the article upon which, we hoped, they were going very largely to build their success—viz., the decolorizer; and the efforts by possible competing firms to learn what this company was doing and proposed to do made it necessary that shareholders in their inquiries should exercise restraint, so that no possible information of use to competitors should leak out. It was proposed to issue new capital immediately.

Mr. J. W. Leadbeater (managing director), in reply to questions, said, with regard to the efficiency of the decolorizer, he was on the safe side in saying that its decolorizing qualities were twice as great as those of the best animal charcoal, and many times greater than those of rough animal charcoal. Of the fuel they had made some hundreds of tons, and it had given satisfaction at every place at which it had been tried. Some of it had been used for glass smelting, and the users preferred it to any other coke they could get, and were paying a bigger price for it. (*Chem. T. Jour.* 1919, Vol. 64, p. 485.)

EXPRESSING WATER FROM PEAT •

J. W. Hinchley, C. S. D. Harper and The Power-Gas Corp. Ltd.
(Br. Pat. 121, 759, Oct. 30, 1917.)

An extrusion press which is particularly suitable for expressing water from peat comprises two narrow vertical rectangular compressing chambers, separated and bounded by hollow walls in which narrow cells extending the full height of the walls are formed. The surfaces adjacent to the compressing chambers are perforated to allow expressed liquid to pass into cells, and the liquid is discharged through pipes at the bottom of the cells leading to a common discharge pipe. The compressing pistons are moved horizontally by a hydraulic ram. Hot gas is introduced into the compression chambers by short valved pipes opening in the top and connected by a common main. The extrusion orifice is rectangular in cross-section with parallel side walls and curved covering top and bottom shutter, attached at one end to a plunger connected to a constant pressure accumulation, and at the other end to a plunger

connected to the cylinder of the ram which operates the compressing pistons. At the beginning of the compression stroke the pressure due to the constant pressure accumulator will preponderate and keep the shutter closed, but when the resistance increases the pressure on the opposing plunger will preponderate and open the shutter. The extrusion orifice is lined with porous ceramic material, backed by perforated plates to conduct the filtered liquid away. A modification is described in which the building up and dismantling are facilitated.

DECOLORIZING CARBON.

J. W. Leadbeater (Br. Pat. 122,698, Jan. 31, 1918).

Decolorizing carbon is prepared by carbonizing a mixture of dried ground peat and lime on trays in a retort, washing with acid and water and then again heating or drying on the trays. The peat may be air-dried, or may be dried in a retort or oven. For carbonizing, the mixture of peat and lime is placed on trays and heated to 550-2000° F. in a retort provided with exits for the gas or other products and fitted with a door or doors. The trays are arranged in single or double rows in the retort and may be arranged to fit one above the other in tiers. They may be wholly or partially closed at the top. To allow the heated gases to pass around the trays, they are smaller in cross-section than the retort and are spaced from the sides thereof by projections provided either on the trays or the walls of the retort. The trays and the projections may be perforated, and when the projections are provided on the walls of the retort the trays may consist of flat plates. The projections on the bottom of the trays may take the form of bowls or rollers.

PEAT CUTTER.

F. Popplewell (Br. Pat. 122,896, Feb. 6, 1918.)

A turf-cutter of the type in which a rotary disk knife is employed, consists of a straight handle to which straight members are secured by bolts to form a fork and the cutting-disk is mounted within the fork by means of bearing brackets for the spindle. The brackets are detachably secured to the members.

PEAT FUEL.

A. B. Serret (Br. Pat. 123,322, Feb. 12, 1919.)

Lime or other oxide of a metal or a carbonate which is

convertible into oxide by heat is mixed with fuel, rich or poor, such as peat, lignite, schist, or mine refuse, for combustion in furnaces or gas producers to obtain a great amount of heat and also, in the form of ammonia, nearly the whole of the nitrogen of the fuel. By causing steam or water to pass over the burning fuel, hydrogen is evolved and combines with the nitrogen to form ammonia, which is collected in the usual way. Nearly all oxides of metals or carbonates which change into oxides by the action of heat are suitable for use in carrying out the process.

DEWATERING PEAT.

A. ten Bosch (Br. Pat. 123,517.)

This invention primarily consists in the method of forcing the pulp of peat by its own weight alone in a continuous flow against a high resistance through an enclosed space, in which the pulp on its way is subjected to heat treatment by steam having a pressure higher than that of the atmosphere, and thereupon compressing the peat by the forcing pressure. The invention further provides for means, or plant for carrying the above method into practice. A convenient and suitable plant comprises a tower or a shaft having a steam supply pipe connected to it, and being provided underneath said steam supply with an outlet for the expressed water, and underneath said water outlet with a discharge for the treated pulp. The plant as specified is extremely simple in construction and operation. All mechanical structures for applying the pressure required to force the peat continually through the enclosed space, i. e., through the tower and the discharge at its bottom, are avoided, and all disadvantages connected with said auxiliary means are obviated thereby, the weight of the pulp itself causing a slow regular feed of the pulp to the discharge end of the tower or shaft. The height of the tower or shaft above the steam supply referred to is such as to warrant a sufficiently heavy pressure upon the treated pulp underneath the steam supply to express the water contained in the pulp through the outlet provided for this purpose, and to force the pulp freed from water through the discharge opening. The height of the tower or shaft may be made to suit the most effective temperature of the steam supplied, independent of its pressure, instead of being used to realize the condition (depending on the extent) to which the water is to be removed. The plant works entirely automatically and continuously, and is very simple in operation.

DRYING PEAT TURVES.

F. T. Warburton (U. S. Pat. 1,290,494, Jan. 7, 1919.)

The length of time occupied by ordinary air-drying processes varies according to climate from three weeks to three months. In some countries, such as Scotland and the mountainous parts of Ireland, the turves cannot be dried at all, because of the dampness of the climate. This inability has led to the adoption of sheds, with shelves on which the turves are laid and raised as above described, but their great cost, and the great expenditure of labor and the difficulty experienced in handling and removing the turves has caused their abandonment. The present process consists in surrounding an elongated drying ground with a light tram road of small cost, over which locomotive fans, such as are used for drying fruit, can travel, and employing low sheds of galvanized iron about 1 ft. high, made in sections which can easily be moved on rails. These will clear the 8 in. by 4 in. by 3 turves when stood on end and leaning two and two against each other. In this limited space the wind produced by the fans will dry every part of the turves on one side, and when the fans are shifted on their rails to the other side, when the turves will be removed to the stack, where they will undergo further drying. As wind is a better drying agent than sun in most peat countries, it is expected that the drying up to stacking will consume but seven days, instead of the three weeks to three months required with the accepted air-drying methods, and moreover that as the low sheds, umbrella-like, protect the turves against rain and damp, this process will enable turf to be dried in all weathers. (Br. Pat. 123,637 and Can. Pat. 188,739 are the same as above.)

CARBONIZATION OF PEAT AND APPARATUS.

G. T. Beilby (Br. Pat. 124,039, Mar. 12, 1918.)

The material is fed by a hopper, into a series of shallow trays, carried by a horizontal rotating frame. The plane of the lower edge of the hopper is horizontal and just above the tray, so that a thin uniform layer of material is deposited on the tray. The trays are pivoted on radial arms, and carry rollers, bearing on a circular rail so that when a gap at one point in the rail is reached, the tray tips into a vertical position and discharges the carbonized material. The speed of revolution of the trays is such that the carbonization is completed in less than a complete revolution. Each tray is brought back to its horizontal position by an upturned portion of the rail which

engages with the roller. The frame carrying the trays rotates within a flat gas-tight metal casing, having an outlet, for the distillation products and enclosed in a heating chamber of brick-work, so arranged that the heating gases pass round the upper and lower surfaces of the casing.

MAKING PEAT FUEL.

J. W. Leadbeater (Br. Par. 124,348.)

This invention relates to improvements in the means and methods of treating peat, so as to render it more adaptable or useful as a fuel than can be used in place of briquettes and like substances that are employed for coal and coke. The object is to produce an artificial or manufactured practically smokeless fuel, which is more porous than briquetted fuel, and which will burn more readily than when a combination of coke or ground coal has been passed through a briquette or like machine in the usual manner. According to this invention, the fuel is composed of about 40 to 50 per cent. of peat, which is mixed with about 15 to 25 per cent. of pitch and about 15 to 25 per cent. of coal or coke. The quantities may be varied within the limits specified, as the nature of the peat requires. The coal or coke, pitch, and peat are separately finely graded or reduced in any suitable manner, say, by machinery of ordinary construction, to a granular form before being used. The pitch and peat are first mixed together, and afterwards the coal or coke is added, and all the ingredients are well mixed together by any suitable and convenient means. After the said ingredients have been well mixed together they are placed in a mould instead of being passed into and through a briquette or like machine, or instead of being placed in a mould the mixed ingredients are placed in a retort. When the mixed materials have been first placed in a mould they are placed in a retort which has been heated to a suitable temperature—say, about 800 to 1,000 degrees Fahr.—that will melt the pitch and remove the tarry matters from the coal and form a porous substance, and produce a practically smokeless fuel. In fuel produced as herein described, the ingredients are bound together by the melted pitch, and the peat acts as an absorbent for the melted pitch. The gases and tar given off during the heating of the mixed ingredients may be collected in a similar manner to that employed in the manufacture of coal gas, and the various light and heavy oils and sulphate ammonia may be recovered by distillation. When the mixed materials have (after the above described heating) become cold and set, the mixture may be used, after being

broken into suitable sized pieces when not heated in moulds, in the same way as an ordinary briquette, and will burn with an intensified heat, and produce a brighter fire, which will give out more heat than the ordinary briquet, and with little or no smoke, waste, or ashes.

NUCLEIC DERIVATIVES FROM PEAT.

W. B. Bottomley (Br. Pat. 124,629.)

In Specification No. 105466 the treatment of peat with an alkaline liquid yields a solution of a nucleate. A solution made by treating peat generally also contains nucleic acid, or a nucleate or derivative of this acid when the solution is treated in the manner usual for isolating this acid. Whatever the nature of the body present in the saline solution, it appears to favor the production of the products called auximones in Specification No. 16658 of 1915, when the peat containing the saline solution is subjected to the action of certain organisms. This invention consists in treating peat with a solution of a salt which is not alkaline for the purpose of obtaining a solution of nucleic acid or a nucleate or derivative or a body yielding nucleic acid or a nucleate. In accordance with the use to which the solution is to be put, it may be left in the peat or separated therefrom. Since an aqueous solution of sodium chloride is apparently at least as useful as any other saline solution for the purpose of the invention, it is preferable for obvious reasons; but an aqueous solution of any other salt such as an alkali chloride or sulphate, an alkaline earth chloride or an ammonium salt may be used. The effect of the saline solution is enhanced by heating the mass of peat which has been moistened or saturated with the saline solution. Advantageously, the temperature of the mass may be raised above 100 degrees Cent. by heating in an autoclave. When nucleic acid or a nucleate or derivative is the objective, the saline solution expressed or otherwise separated from the peat is worked up in the known manner. When the treated peat is for manurial use, it may advantageously be inoculated with nitrogen fixing organisms, or with micro-organisms, capable of producing ammonia or other suitable organisms; for instance, yeast. And there is advantage in mixing the peat before or after the treatment with an insoluble phosphate or a basic slag before the inoculation, such mixing being preferably followed by heating in an autoclave or otherwise preparatory to the inoculation.

PEAT FUEL.

H. P. K. T. Nielson (Br. Pat. 125,083, Mar. 30, 1918.)

Raw peat, treated if necessary with water so as to make it of porridge-like consistency, is ground thoroughly in a ball mill, tube mill, or other mill, until the cellular structure of the peat has been destroyed. The water is then drained from the ground mass, which may be dried during or after a moulding process.

PRIZE FOR FINE BLUEBERRY PLANTS.

Our society has been requested to assist in an investigation being carried on by the U. S. Department of Agriculture, in co-operation with a few private persons, as outlined below. As most of our agricultural members are aware the blueberry plant gives excellent results on acid peat soils, in fact some of the best blueberries are cultivated around peat swamps. We understand the work, being carried on in this direction, has progressed to a point where in a few years this industry may be on a solid basis.

At present an effort is being made to locate a number of particularly fine wild plants in all parts of the country for further experimentation and breeding. Because officials of the Department of Agriculture are not permitted to offer prizes for wild plants, this search is being conducted by Miss Elizabeth C. White of New Lisbon, N. J. and Mr. A. E. Morgan of Dayton, Ohio, who will turn the best plants over to Mr. F. V. Coville of the Department of Agriculture for his work.

Blueberries are commonly known in the South as huckleberries and the interesting feature to our readers will be that the blueberry plant grows and bears best in an acid soil where ordinary crops would not do well.

For several years past Mr. F. V. Coville, of the United States Department of Agriculture, and Miss Elizabeth C. White, of New Lisbon, New Jersey, have been cultivating blueberries and working to produce new and better varieties. To get new varieties they find the very best wild bushes and then cross-breed these wild plants. The seed resulting from the cross breeding grow into all sorts of new varieties, just as seedling apples are seldom like the tree they came from. Many of these new varieties of blueberries are poorer than their parents, but about one in a thousand turns out to be much better than either parent and makes a promising new variety.

About ten years ago the Department of Agriculture published Mr. Coville's work on blueberry culture. His most surprising discovery that blueberries cannot live in a well-balanced, fertile soil. They require a sour or acid soil and they

are actually killed by the application of fertilizer which would be the best possible food for ordinary plants. Some years ago a wild blueberry plant was found in Massachusetts with berries more than three-quarters of an inch in diameter, but it was killed by people who did not understand its proper care by being fertilized.

Since 1911 Miss White has been associated with Mr. Coville in these investigations, he in the Government greenhouses at Washington working out the scientific problems and originating new varieties by cross-breeding, and she at New Lisbon, New Jersey, raising these new varieties and the best wild plants that could be found. Mr. Coville and Miss White are now trying to find a number of wild plants to use for this work. They already have a few plants that have berries three quarters of an inch through, and hope to produce hybrid berries an inch in diameter. They want more unusually fine wild plants, and will pay \$50.00 for especially fine plants with very large berries.

But it is not only the size of the berry that counts and they are willing to pay smaller prices for plants that have many berries of slightly smaller size if these berries are of unusually fine flavor. Some bushes bear much more heavily than others. On some bushes the berries stick so tight that when they are picked a piece of the stem pulls off with the berries or the berry is torn and the juice leaks out. On other plants the berries come off the stem just right. Berries from some bushes spoil soon after they are picked, while others will keep for a week. Some berries are black and others of a beautiful light blue color. There are doubtless thousands of bushes in the country with berries three-quarters of an inch in diameter, and many other bushes with berries just a little smaller but of unusually fine quality, but it is only by having people on the watch for them that these fine bushes can be discovered.

The fine varieties developed by cross-breeding will be distributed by the Department of Agriculture to persons who have learned enough about cultivating wild blueberries to show they can handle the new variety with success.

Persons who are interested in finding such plants should write at once to Miss Elizabeth C. White, of New Lisbon, New Jersey. Miss White will send full directions, with measuring gauges, and bottles of formaldehyde for mailing large berries that are discovered.

Through the efforts of Mr. Coville of the United States Department of Agriculture, in co-operation with Miss White, the cultivation of blueberries will probably be well established in a few years.

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If you are interested in any degree whatever in Agriculture, Power and Fuel, Chemistry or any other uses of Peat, you should let us help you and you help us by becoming a member of the American Peat Society.

OBJECTS AND FOUNDATION.

Founded at the Jamestown Exposition on October 23rd, 1907. Its object is to further the interest in the uses and application of peat for industrial and economic purposes.

PUBLICATIONS.

The Society holds one general meeting per year, and publishes a Journal quarterly, which is sent to all members in good standing. The journal includes the proceedings of the meetings, original papers on practical experience, etc., also abstracts on all contemporary literature and patents, thus all the latest agricultural uses, fertilizer purposes, drainage, fuel, uses, technical uses, etc.

SOME ECONOMICAL POINTS OF INTEREST.

Prof. Chas. A. Davis, U. S. Bureau of Mines, estimated that there are about 12,000 sq. miles of workable peat beds in the United States, outside of the large number of beds very advantageously adapted for agricultural purposes, etc. He gave as a conservative estimate a yield of 200 tons dried peat per acre foot.

Canada has at least 37,000 sq. miles of known peat deposits.

About ten million tons of peat are used in Europe each year.

GENERAL INFORMATION AND INQUIRIES.

All members have the privilege of making inquiries regarding general information about peat and its uses, by addressing the Secretary of the Society.

It must be understood that only general information and of a general character can be given. Members can obtain the names of experts in any special line, from the Secretary of the Society.

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